THE LIFE-HISTORY OF THE SALMON

F. GRAY GRISWOLD

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1930.

THE LIFE-HISTORY OF THE ATLANTIC AND PACIFIC SALMON OF CANADA

MAP SHOWING LOCATION OF THE SALMON RIVERS OF CANADA.

The Life-History of the Atlantic and Pacific Salmon of Canada

BY
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and
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To the
HON. JOHN HALL KELLY, K.C.
The Ambassador and Friend
of *Salmo salar*

FOREWORD

THE powers that be in Canada do not appreciate what a valuable harvest they might have from their salmon fisheries if the approaches to the rivers were managed in such a way that the salmon might be allowed to arrive and multiply in a normal manner.

This is prevented by over-netting.

I have often heard it said that it was not worth while to preserve the salmon, that salmon fishing was simply a sport of the idle rich, and that salmon as a food was a needless luxury.

The combined rod catch of the three chief salmon streams in Eastern Canada, the Ristigouche Club, the Moisie and Grand Cascapedia, during the great year of 1925, was 5,008 salmon. The unreliable reports from the nets in the Provinces of Quebec and New Brunswick the same year totaled

5,078,700 pounds. Estimated at 10 pounds to the fish it totals 507,870 salmon!

Mr. J. Arthur Hutton, the celebrated English authority, says in his book:[1]

" Salmon is not a luxury, but a cheap form of food. For example, compare salmon with cod. There is very little waste in salmon, the skin and bones amount to 23% only. With cod, on the other hand, the wastage is 49%. Then again the flesh of the salmon is very nutritious, one pound containing 700 food calories compared with 166 in one pound of cod, so that when the price of salmon falls below $1 a pound it is cheaper than cod at 25 cents."

The authorities in Canada lease the fishing rights in the rivers for large sums. For example, it costs us $38,000 a year to run our river. By licensing too many nets they allow most of the salmon to be captured before they reach their rivers. Under the circumstances this does not seem quite sportsmanlike.

[1] *Life History of the Salmon,* University Press.

Mr. Hutton says further:

" The only cost of the fish harvest is that of catching them. Nature hatches out the fish, rears and fattens them. No other food harvest is planted, grown, and garnered with so little trouble and expense."

Nature is ready to provide man with a rich fish harvest, but cannot accomplish her purpose when man captures the majority of the salmon before they arrive on the spawning beds.

Salmon are very stupid fish, and their habits are such that they are always at a disadvantage. When they first arrive off the coast they are loath to enter their rivers, and " mill " about off shore, swimming in shoals against the tide. This enables the miles of drift nets to capture them by the thousands.

Then again, as they approach the coast they encounter the standing gill-nets. As they swim back and forth against the tides they become gilled on both sides of these nets.

It is a wonder that any fish eventually

arrive in fresh water. Many that do succeed bear gill-net marks.

If the authorities would reduce the number of days that netting is allowed, and reduce the thousands of fathoms of drift-nets which they now license, both the netters and the anglers would soon enjoy better fishing.

What is good for the fish is good for the fisherman, and what is of benefit to the angler also, in the end, benefits the net fisherman.

The river Wye in England has been completely resuscitated by limiting the netting to three days a week.

Our fish have a doubtful free fairway on Sundays only.

STATISTICS

The importance of the Canadian salmon fisheries is very great, and it behooves the authorities, if they are wise, to make it far greater.

The reports of the nets of New Brunswick

and Quebec from 1911–1928 account for 554,873 cwt. of salmon. At an average of 10 pounds to the fish it totals 5,548,730 salmon in 17 years!

In 1907 there were 4 boats, using 2,400 fathoms of drift nets, in the waters between the Miramichi River and North Point, Prince Edward Island. In 1925 the boats had increased to 52, and the nets to *35,000 fathoms*. It is said there are now (1929) 123 boats along the coast, each *restricted* to *750 fathoms* of nets! Fishing is allowed from May 16 to July 31 — practically during the full run of the salmon.

MIRAMICHI NETS

1925 52 boats 3,534 cwts. Drift 4,430 cwts. Set Nets
1928 88 " 2,692 " " 1,178 " " "
1929 113 " 4,342 " to June 30 933 " " "
The run was light in 1928 and 1929.
In 1925 35,000 fathoms of Drift nets
" 1929 84,950 " " " "

THE SALMON

THE SALMON

ALTHOUGH the salmon that frequent the rivers of Canada are of the same species as those that run into the rivers of Great Britain, their habits differ owing chiefly to weather conditions.

Our rivers freeze in winter, but those of Great Britain do not, so that our fish have but one short season in which to fulfill their chief desire, namely the continuance of their species. In other words, the salmon of Canada enter the rivers at one season only, and have but one spawning time.

In Great Britain they have more than one run of salmon during the year. In the large rivers of the East coast of Scotland there is a Spring run as well as one late in the season. In fact there is no month in the year during which the fish do not ascend these rivers, yet the small streams see no salmon before the month of March.

The English and Scotch salmon are divided into Spring fish, small Summer fish, and large Summer fish, which arrive at different seasons. There is no such distinction in Canada. The different sizes of fish follow one another in close order. In the Cascapedia the large females arrive first, and are closely followed by the large males and the maiden fish.

Nature provides that the henfish arrive early, for with fully developed ova the upstream journey becomes too arduous.

The more we study salmon the more we have to realize the very considerable amount of time which they spend in the sea, yet it has never been discovered where they dwell in salt water.

The salmon of Canada go into the Atlantic Ocean, but the fish of Scotland and England have the North Sea also as a possible habitat. This may partly account for their different habits, for the water temperature differs along the coasts of Great Britain in these two bodies of water.

Mr. Menzies [1] tells of a 25-foot shark that was captured off Peterhead in August, 1911, containing 10 salmon from 10 to 12 pounds each, and it is known that the Dogger Bank fishermen sometimes take salmon in their nets.

The first salmon arrive off the coast of Nova Scotia early in April, and enter the Medway and other rivers, but the St. Lawrence and the Bay of Chaleurs fish do not appear until late in April. They remain in salt water, swimming back and forth against the tides, until the temperature and strength of the river water is agreeable, before they attempt the upstream journey.

The Cascapedia fish wait until the snow water has run out. This season — 1929 — the first salmon was taken in the Carleton nets, near the mouth of the river, on April 23. The first fish taken on a fly in the lower waters was on June 5, and on the Club waters on June 18, when the temperature of the river water was 47°.

[1] *The Salmon,* Blackwood.

It appears as if the river water must be above 45° before the fish run up freely, and they do not enter the tributaries of a river until later, as their waters are colder than those of the main stream.

There are early rivers and late ones. The reason for this is not fully known. Buckland claimed that the seasonal character of a river depended on its length in proportion to the square mileage of its drainage area, but later observers believe it depends greatly on water temperature.

Early in the season the river water is much colder than the sea, but on an average river water is only 4° colder than sea water.

In the Cascapedia the salmon take the fly readily when the water is between 45 and 55°, but do not rise freely if it is much warmer.

THE SALMON

(*continued*)

THE SALMON

(*continued*)

LITTLE was known concerning the life of the salmon prior to 1904. What had been believed was mere surmise. It was supposed that all the fish that survived in the sea increased in size, and returned year after year to the rivers to spawn.

There was also a difference of opinion concerning the young salmon. In early times the *salmon parr* was given the name *salmo salmulus,* for it was considered to be a small member of the salmon family, but was not recognized as being a young *Salmo salar.*

In 1904 Mr. H. W. Johnston published an article in the "Field," describing his discovery that the life history of the salmon could be told by the examination of the fish's scales, and scale-reading became a science. It is not a difficult science, and a microscope

is not needed, yet much practice is necessary to become proficient.

Select a perfect salmon scale, wash it clean, place it on a piece of glass and examine it with a magnifying glass. You will find that the scale has a center, or core, consisting of fine lines, some close together, others wider apart. This part of the scale represents the fresh-water life of the young salmon, or *parr,* before it goes to sea as a *smolt.*

Each couple of zones of lines represent one year in the river. The close lines the winter feeding, and those that are wider apart the summer forage. Count the zones only — the lines do not always run true.

When a small fish receives scales they are numbered, and as the fish increases in size the scales must also increase in size, for they do not increase in numbers.

The scale grows larger by the formation of ridges around its outer edge. These ridges, or lines, are very close together on the parr scale, for their food is meagre and they grow

slowly; but when they go to sea as smolts, and find a goodly supply of food, the ridges become more pronounced, especially during the summer time when the food is plentiful.

If you examine the scale of a maiden fish you may ascertain how many years it has remained in the sea since it left the river as a smolt, by counting the winter and summer zones, and you may estimate its total age by adding these to its smolt age.

During their stay in the river with little or no food, and after the severe strain of spawning, the salmon lose much weight. Many die from exhaustion. Most of the large male fish perish.

As they decrease in bulk, the scales fray at the edges and become ragged. The survivors return to the sea, as *kelts,* and there recuperate rapidly with good food, and increase both in length and bulk. The scales mend and begin again to acquire fresh rings, but a scar, called a *spawning mark* is left. The number of such scars represents the number of times a salmon has spawned.

Few salmon spawn more than once, but this differs in different rivers. About 2% return to most of the rivers in Scotland, yet it has been found that nearly 50% of the salmon in the small river Add spawn more than once.

In Canada a study of the scales of but two rivers has been made, namely those of the Moisie and of the Grand Cascapedia. In both these streams but 15% of the scales examined showed returning fish.

Very few salmon spawn more than twice, and the examination of many thousands of scales has produced but 8 fish that had returned for the fourth time.

It was supposed that the limit in the age of a river salmon was 8 years, but a fish has been found that was over 13 years of age.

The reading of fish scales is not confined to the salmon, for even the eel has tiny scales underneath its skin which tell its age.

By marking smolts and kelts it has been discovered that 99% of the fish that return enter their native rivers.

Mr. Hutton writes me:

"I believe that salmon try to get back to the very spot where they were born. We have a record from Loch Lomond of a sea-trout being caught (for hatchery purposes) in the same identical spot in three successive spawning seasons, having gone down to the sea during the intervening periods."

A wise provision of nature is that the salmon that enter a river in any one year, for the purpose of spawning, are the product of at least 8 years hatching. Nature in this manner prevents the destruction of the breed by the failure of any one year's harvest.

The netting rights of the Moisie River were held some years ago by an Irishman who was displeased with the size of the fish. He imported spawn from a large-fish river in Ireland, and planted it in the Moisie. We know from rod scores that still exist that in the 1850's the average weight of Moisie salmon was 15 pounds. The average weight of fish taken in 1927 was 19 pounds, showing that it is possible to improve a river's fish.

It is said that many years ago Frank Buckland introduced 700 young salmon from the Rhine into the waters of the river Wye. Within five fish generations the salmon in the river became larger, and ran earlier; yet, as the Rhine salmon do not take the fly, the introduction of these alien fish may be the reason why the salmon in the Wye prefer "bait" to flies at the present time.

CLASSIFICATION

CLASSIFICATION

ALEVIN	The tiny creature when first hatched.
FRY	The little fish five weeks later, after having absorbed its yolk-sack.
PARR	A little later, having acquired scales and finger-marks.
SMOLT	The migratory fish having adopted a silver livery.
GRILSE	The precocious fish that return after being one year in the sea.
MAIDEN FISH	Salmon on their first return to the river.
SPAWNED FISH	Those that have previously visited the river and have returned again.
KELT	Salmon in poor condition owing to fatigue of spawning. " Spent " fish.
MENDED KELT	In Canada, a kelt that has

	wintered in the river and has acquired a bright livery.
BAGGOT OR RAWNER	A henfish full of unshed ova.
DROPPER	A salmon that temporarily deserts fresh water and again enters the sea.
BLACKFISH	A diseased salmon. Often caused by blindness.
UNCLEAN	A fish nearly ready to spawn or having just spawned.

SPAWNING

Seventy-five per cent. of the salmon that arrive in our river fight their way upstream to the spawning beds, or redds, above Lazy Bogan. Here, and in the upper branches of the main stream, they spawn in late October and early November. Those that remain in the lower pools, and the late arrivals, spawn all along the river.

Prior to the actual spawning period the salmon gradually acquire a camouflage of black, red, and copper color, the scales sink

into the skin, which is covered with a thick mucus, and both the upper and lower jaws of the male fish become greatly prolonged.

In the course of spawning the female salmon lose from one-quarter to one-third of their weight, and the males become weak and emaciated.

The spawning takes place in strong water two or three feet deep. The henfish selects a place with fairly large gravel and stones, for sand or fine gravel would smother the eggs. The henfish do all the work, as the cockfish pass their time fighting.

The female, having selected her nest, comes to the surface, arches her body and on her side wriggles upstream as she exudes her eggs, throwing up gravel and stones as large as goose-eggs. She is enabled to do this owing to the specific gravity of stones under water, and with the assistance of the river current.

This is repeated every few minutes. The male follows and fertilizes the eggs. These actions continue for six days or longer, as all the eggs do not ripen at the same moment.

Ultimately the bed is three or four yards long, and the eggs are covered with stones. The female then leaves the redd, and the male watches it for a time unless enticed away by a fresh female.

The loss of eggs in the hatcheries has been reduced to 1%, but in the river it is far greater, for they are devoured by trout, eels, and other fish. Floods may destroy them, or droughts may leave the redds high and dry, and the ova exposed to the frost. For this reason nature provides that a henfish may exude nearly as many thousands of eggs as she has pounds of weight.

Each egg resembles a small, translucent elastic ball, and, if fertile, sinks. The unfertile eggs float downstream and are devoured by the trout. If the eggs are not fertilized by the male they become water-logged and opaque.

The eggs lodge in the crevices between the stones until they hatch. A constant current of water is necessary to supply the oxygen which is needed to complete the hatching.

This period depends on the temperature of the river water. If the water is about 48° the eggs hatch in 100 days. If the water is colder, the process takes longer. The average of possible hatching is believed to be about 15 weeks.

Low water conditions are the best for spawning, for then the eggs must be deposited in the river bottom and out of harm's way.

Salmon eggs placed in brackish water, two parts of sea water to one of fresh, will not hatch.

ALEVINS

Probably 50% of the eggs are not fertilized. Those that are hatch in about three months, and each egg produces an *alevin* less than an inch long. These helpless, tiny creatures have yolk-sacks attached to them. They subsist on the contents of their sacks for from six to eight weeks, and then become *fry*.

FRY

The finger-marks now begin to appear, and the fish acquire scales. The length of time that passes before the fry begin to feed on insects depends on water temperature. Nature provides that no food is required until it is plentiful. When the following winter comes the fry become dark in color, and hibernate among the stones.

PARR

The following spring they have the true coloring of the parr and are often mistaken for trout. They are, however, more graceful than trout of the same size, have fewer red spots, their adipose fin is not tinged with orange and red as with the trout, and the latter has a larger mouth.

The further north the river the slower the parr develops, for it is a question of short summers, cold water, and poor food.

The greater part of the parr in Great Britain go to the sea as *smolts* when two

years old, but it has been found that the parr in some of the rivers of Norway and Canada remain three or more years in fresh water before thay are fit for the sea.

From what we know of the Grand Cascapedia 58% of the parr become smolts when three years old, 34% at the age of four, and a few remain in fresh water for five years. This is supposed to be caused by short summers and lack of food, yet the Moisie River, which is further north, sends 56% of her smolts to sea when two years of age.

The parr have many enemies. Small boys, kingfishers, merganzers, and other birds take heavy toll, but their worst enemy in Canada is the sea-trout, or *charr*. These fish not only compete with the parr for food, but devour the little fish in great numbers.

SMOLTS

When a parr acquires a migratory impulse it gradually assumes a silver coat and a blue back. These cover its spots and finger-

marks. The change is, however, only surface deep. If the scales are removed the parr markings are still to be found on the skin underneath.

A parr does not become a smolt unless physically fit to run the dangers of the deep. This depends on the food it has been able to find, and on its consequent growth.

It may happen at the end of one year or at any following spring up to five years. The further north the river, the colder the water, the less the forage and feeding time, and the greater is the smolt age.

Although the two-year-olds predominate in most rivers, three-year-olds and four-year-olds are not uncommon.

The river Wye in England is 150 miles long. Six per cent of its parr migrate when twelve months old, 89% reach the smolt age when two years old, and only 5% remain in the river for three years. This means that the food in the Wye is plentiful.

The Moisie River in Canada shows that

56% are two years old and 39% three years of age.

The Grand Cascapedia scales that were examined lead one to believe that but 6% leave the river as two-year-old smolts. The three-year-olds form 58.8%, and the four-year-olds 34.1% of the total.

This means that the Cascapedia is a rocky bottomed, rapidly running stream, in which little vegetation can possibly grow, and that the supply of food is poor. The parr remain a long time in the river at the mercy of their many enemies. It also means that everything should be done to protect them. The birds of prey should be destroyed, and the sea trout eliminated.

The length of the smolts differs in different rivers.

The older the smolt is when it goes to sea the sooner it returns. The well-fed, well-grown smolts are those that go to sea first, and being exceedingly healthy subjects, they are the ones that remain in the sea, enjoying the good food with no early thoughts of re-

production. In the Cascapedia these fish return as maiden, six-year-old salmon, and weigh from 20 to 30 pounds.

The parr that have had a harder struggle for existence remain in the river for more than three years. They return sooner, and are smaller in size.

We ought to do everything possible to protect the early maturing type of fish if we desire to preserve the average weight of our salmon.

In Scotland it is said that the smolts assemble at the top of the tide, and depart in detachments during May and June. They may be present in thousands one day, and the following day none are to be seen. Where they go in the sea is a mystery.

I have never met anyone who could advise me as to the habits of the smolts in Canadian rivers. Our head guardian has never seen a smolt in the Grand Cascapedia. Their migration must take place in the early spring under the ice.

The mortality of smolts in the sea must be

very great. Mr. Calderwood marked 6,500 smolts in the Tay in 1905, and but 110 were recaptured as adult fish.

GRILSE

It was formerly supposed that the smolts went down to the sea in the spring and returned as grilse in the summer and autumn of the same year, but scale reading has corrected this belief.

A grilse is a precocious, adolescent fish that returns to its river after a little more than twelve months feeding in the sea.

The age of a grilse depends on its smolt age added to its one year in the sea.

Grilse weigh in Scotland from 5 to 13 pounds, but in Canada are smaller. This depends on the river and the food they have been lucky to find in the sea, and also probably on their parentage. In late years the run of grilse in Scotland has greatly decreased, and the reason for this is not known.

To recognize a grilse surely, its scales must be examined, but there are certain out-

ward signs which afford clues to their identity.

The tail is forked, the "wrist" of the tail is slender, and the scales shed readily. Their fins are also somewhat larger for the size of the fish, which I believe is why they are more active than salmon of the same weight.

Grilse are fast swimmers. A grilse that was marked at the entrance of Inverness Firth travelled to the estuary of the Forth, 250 miles, in 7 days, or at a rate of 35 miles a day. They are also wonderfully clever in avoiding the nets.

In Canada only some rivers contain grilse. They are plentiful in the Godbout, and 10% of the fish taken on the rod in the Ristigouche are usually grilse, but none are ever found in the Moisie or the Grand Cascapedia. The reason for this is not known, but it probably accounts for so many large salmon in those rivers, for their average weight is 19 and 23 pounds.

Of all the grilse marked in the sea none have ever been recaptured as maiden fish.

There is a greater proportion of males than females among grilse. This proportion differs in different rivers.

All grilse, excepting perhaps the "droppers," are supposed to spawn.

MAIDEN FISH

A maiden fish is recognized by its great beauty — silver brightness — and because it seldom has more than one or two black spots on its gill covers, or below its lateral line.

If you examine the gills of a fresh-run maiden fish, you will find them quite sound and clean, and blood red in color. Maiden fish are far superior as food to fish that are running in for the second or third time to spawn, the flesh of which is pale in color and lacking both in fat and flavor.

The age of maiden fish depends on the number of years they have remained in the sea added to their smolt age. They may be from four to eight years old in Canadian rivers, and vary according to the quality and quantity of food they have been able to

obtain. Occasionally one finds a large fish that has been in the sea for five years without spawning.

The average weight differs in different rivers and in different years. Small rivers usually have small fish, and large rivers big ones.

Each river has its own type of salmon. They are " geared " to their own individual river, which means that after long years of natural selection and the survival of the fittest, a type of fish has developed which is best able to surmount the difficulties of its native stream.

More than one type of fish may be found in a river, for those tributaries which harbor salmon also develop their own individual type.

The Ristigouche fish differ in shape and in average weight from the salmon of its tributary, the Matapedia.

The salmon harvest depends mainly on maiden fish, so that the annual run is most important.

PREVIOUSLY SPAWNED FISH

The salmon might be described as a rapidly growing fish which reaches maturity at five or six, goes once to its stream to spawn, and then dies, yet an uncertain number survive and return again.

These fish on their second or further return can be distinguished by their looks. They are not as silver bright as maiden fish, and their scales appear to be more prominent. They have tattered, dark-reddish-brown gills, containing a few fresh-water gill-maggots, and also have numerous irregular black spots on their gill covers and along their sides. The male fish have pronounced hooked jaws.

Their flesh has not the full-bodied red color of the maiden fish, and they are poor table food.

The returning salmon are mostly henfish, for the majority of the large males perish, after spawning the first time.

The numbers that return differ according

to season. We have very little data on these subjects in Canada. Of the scales that were examined by experts, 16.7% of the Moisie were returning fish. 182 Grand Cascapedia scales showed 48 second spawners and 14 third. In Scotland 93 out of every 100 salmon are maiden fish.

Few salmon return twice, very few three times, and only 8 have been found among the collections of thousands of scales from the rivers of the world showing four spawning marks.

The oldest fish ever found was a little over 13 years of age.

KELTS

After spawning in the rivers of Eastern Canada, the salmon become emaciated and unpleasant looking objects. Those that survive drift later slowly down to the sea, tail first, and there recuperate and regain their brilliant silver livery.

After spawning, the females lose from one-quarter to one-third of their weight and

remain for a time in the deep pools before drifting down stream.

The males remain for an indefinite period on the redds. They are much more exhausted after spawning than the females, and their death rate is very high.

Some kelts make for the sea with little delay, while others in some rivers remain throughout the winter and go to sea the following spring as *mended kelts.*

MENDED KELTS

In Canada a mended kelt is a kelt that has wintered in the river and has partly recovered its well-being. As a rule, these mended kelts have regained a bright coat, but this sheen is one of tin rather than of silver.

It is often difficult to distinguish them from fresh-run fish. They have fresh-water gill-maggots, and although they may appear to be plump it is the result of absorption of water and not of food. The scales from a well-mended kelt show no sign of any new growth.

There are few mended kelts in the Ristigouche and the Moisie, but they are numerous each season in the Grand Cascapedia. They disappear about June 25.

Of the many thousands of kelts marked in Scotland only about $4\frac{1}{2}\%$ have been found when again clean. It is estimated that 90% must perish in the sea. No Grand Cascapedia marked kelt has ever been recaptured.

PARASITES

Fresh run salmon bear sea lice. These pests do not breed or live in fresh water. They remain attached to the fish for about a week, and then perish.

When in the river, salmon are attacked by fresh-water gill-maggots. When the fish goes back to sea as a kelt, some of these, being well nourished, survive, but they do not breed in salt water. The gills of returning spawned fish plainly show the havoc created by these parasites.

WEIGHT

The heaviest salmon ever taken in Canada was the Grand Cascapedia fish of 54 pounds landed by Mr. R. C. Dun on June 20, 1886. Since then there have been only three fish taken over 50 pounds in weight. Since 1910 I know of 58 salmon over 40 pounds on the Club waters, and some 950 over 30 pounds each.

The average weight of the Moisie fish is about 19 pounds, and of the Ristigouche, 18 pounds, and its record fish, 48 pounds (1925).

It is rare to find a henfish more than 30 pounds in weight, for they seldom remain more than three years in the sea. Those over that weight are usually "spawned fish."

The very heavy male fish have as a rule remained in the sea for four or five years. The greater part of the Cascapedia maiden fish are six years old, 3–3, one year older than those of the Moisie. Of the Ristigouche we know but little.

CONSERVATION

CONSERVATION

MANKIND is by nature wasteful, and the citizens of North America are by habit the most improvident people of the world. The salmon, once so numerous in the rivers of the United States, have all long since been destroyed by sawmills and river dams. A few years of this treatment destroyed the spawning beds, and banished all the salmon.

The day is fast approaching when the salmon of Eastern Canada will be in great danger. The wasteful destruction of the timber, the demand for waterpower, the damming of the rapid streams for the purpose of producing electricity, the increase in the population and consequent pollution, will all tend to destroy the fish.

The provinces of Quebec and New Brunswick are becoming rich through prohibition and the traffic in liquor, and will soon not

need the large sums now received from the rod fishermen, and the citizens of Canada are demanding the right of free fishing in their native rivers.

When that day arrives the salmon will be in great jeopardy. The conditions in Eastern Canada will follow those in Nova Scotia of the present day. The rivers will still flow but salmon will cease to run.

The lessees of the fishing at the present day do their utmost to preserve the salmon. They employ guardians at great expense to watch the rivers and the spawning beds, and many limit their daily and yearly catch. In this manner they do what they possibly can to preserve the parent stock. The lessees also expend large sums in leasing and doing away with those nets in and near the estuaries of their respective rivers that interfere with the approach of the salmon.

The government is not so kind to the salmon. It licenses hundreds of miles of drift nets, and of standing nets, in the sea, which

prevent a sufficient number of fish from reaching the rivers and the spawning beds in order to plant the seed that is absolutely necessary for the continuance of the species.

SALMON (*Salmo salar*) OF THE RIVER MOISIE (Eastern Canada)

BY

W. J. M. MENZIES

SALMON OF THE RIVER MOISIE

INCLUDED in the area of distribution of *Salmo salar* are the western coasts of Europe as far south as the Franco-Spanish border as well as the British Isles and Iceland, and, in addition, the eastern coast of Canada and the United States down to the State of Maine. A very large number of investigations have been made in Great Britain and various European countries, both by marking the fish in order to trace their subsequent growth and movements, and by reading their age and history from the scales. Length calculations from scale measurements have also been made in Scotland, Norway, and Sweden.

Certain marking experiments have been made with *Salmo salar* as a subject both in Canada and the United States, but, so far as I am aware, no effort has been made to deal with their scales, or if so, no results of such investigations have been published.

I therefore approached with some care a small collection of scales of salmon from the river Moisie which flows into the north side of the Gulf of St. Lawrence. Unfortunately the collection could not by any means be called representative, since the sample I have to deal with consists of particulars of only 120 fish caught in 1922 and 257 taken in 1923, while other details of the catch which were supplied to me showed that some seven or eight thousand fish may be caught by nets and rods in the course of a short season of about two months.

The period of collection also of these small samples did not extend throughout the season, but was confined to about a month. One was therefore at a grave disadvantage in the examination of scales, not only from a strange river but also from another country. As a preliminary measure it was only possible to use accustomed methods, but after trial the formation of the ridges and zones of growth were seen to resemble exactly that of the scales of salmon of this country, and

no special difficulties arose in reading the apparent age.

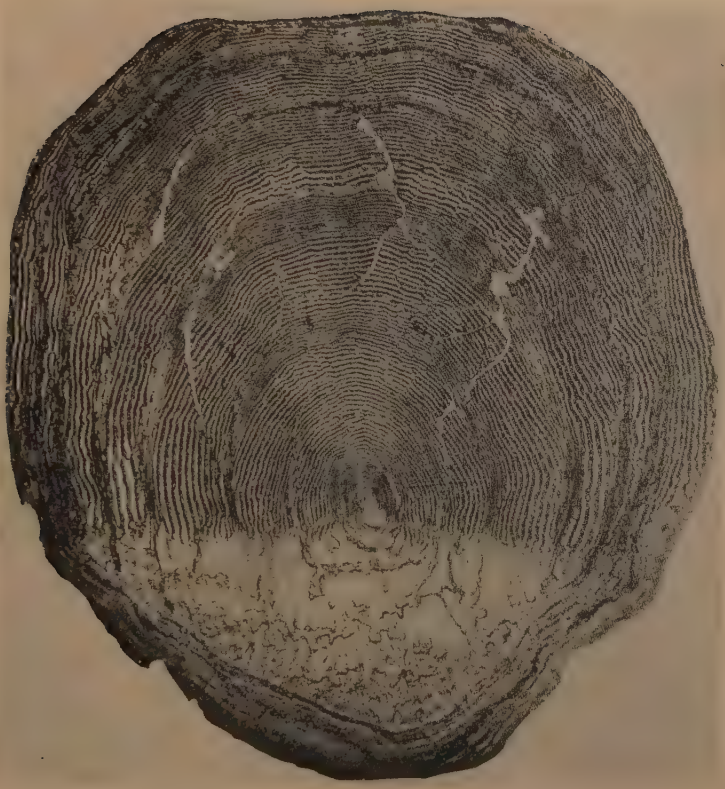
In such rivers as the Moisie, subject to extreme climatic conditions and liable to prolonged and severe cold during the winter months, one does not know in what manner kelts may behave after spawning. I approached the subject of the spawning mark on the scales with the possibility in my mind of a rapid migration from the river by the kelts immediately after the completion of the redds. I was prepared to find a somewhat less definite scar than is usual on the scales of previously spawned fish caught in this country. Fortunately, among the collection sent were the scales of three kelts and a " baggot " (*i.e.* an unspawned female), all caught in late spring or early summer, and these seemed to suggest that some kelts at least spend the winter in the river.

Acting on the assumption that a spawning mark is shown by all fish which have spawned and have again returned to the river as clean fish, I find that of the total of 377 salmon, 63,

or 16.7 per cent., fall into this category. This proportion is very much higher than we are accustomed to find in the rivers of the east coast of Scotland, where it is very unusual for more than 5 per cent. of the stock to be on other than their first return to fresh water.

Of these 63 Moisie salmon, 35, or 9.3 per cent. of the total sample, had spawned once; 11, or 2.9 per cent., had spawned twice; 16, or 4.2 per cent., had spawned three times; 1, or .3 per cent., had spawned four times.

The numbers of salmon which survive to return to the Moisie for a third and fourth time are noteworthy, and more especially is this so in the case of the single fish which had spawned four times, and was on its fifth journey to the river when netted and killed. Of all the scales examined in Scotland, we have records of only three fish which had helped so materially in the reproduction of their species. Two were clean fish, one of 19 lb. from the Conon, and another of 29½ lb. from Loch Maree; the third was a kelt of 12 lb.



RECORD MOISIE SALMON
On fifth journey to spawn
14 years old

caught in the Add in Argyllshire, which, since it was again in the kelt stage, had spawned on five occasions. The Moisie fish weighed 38½ lb., and, like the Scottish fish was a female. Its scales show two years of river life, followed by apparently three years in the sea and then a full year's feeding between each spawning period — that is, it adopted the long-absence habit and spawned biennially, descending as a kelt in the spring of one year, and remaining in the sea until the spring or early summer the following year. Its total age was consequently thirteen years.

As absorption of scale material during the freshwater fast may remove evidence of a complete winter's growth, the age of any of these spawned fish at the time of their first ascent of the river cannot be estimated with absolute certainty, but, as far as can be judged, 58 of the 63 fish spawned for the first time after spending three winters continuously in the sea.

The average age at migration of the Moisie smolts is slightly higher than is usual in the rivers of the north-east of Scotland, but is lower than is found in Norway. In Scotland the majority of smolts are two years of age, but in certain districts as many as 25 per cent. of the total may be three years old. In Norway, the proportion of three-year-old smolts may be as high as 75 per cent. In the Moisie, the percentages of two- and three-year-old migrants were 56 and 39 respectively; the remainder, consisting of those four years old, formed 5 per cent. of the whole, while one fish had spent five years as a parr in the river.

Summary

The analysis is based on a rather small collection of scales and measurements which may possibly be not quite representative of the salmon (*Salmo salar*) of the river Moisie (East Canada).

The portions of the scales representing both river- and sea-life are easily read, and

closely resemble the scales of European salmon in formation and growth, but it is not possible to decide, from the material available, if the periods of slow and rapid growth correspond with the winter and summer seasons respectively.

The majority of Moisie salmon return to the river after spending three winters in the sea; some may do so after an absence of 2+ winters, but those which spend 2, 3+, and four winters away from the river are rare, and apparently grilse (1+ winters group) are entirely absent.

Erosion of the scales during the period of abstinence prior to spawning takes place normally, and a spawning mark is subsequently formed on the scales in the usual manner. The number of fish on their second or subsequent return to the river (16.7 per cent.) is high, and the number which have spawned more than once (11 twice, 16 three times, 1 four times) is relatively considerable.

The average age of the Moisie smolts is

intermediate between that of the smolts of N.E. Scotland and of Norway; 56 per cent. were two years, and 39 per cent. three years, old when they first entered salt water. The balance were four years of age, with the exception of one, which had spent five years in the river.

The average sizes of the 2+ winters group, 9.15 lb. and 29.4 inches, are considerably less than the averages of fish of the same history in Scotland, but the result may be affected by the period of the season at which the samples were taken. In the older group of 3-winters fish the averages, 20.7 lb. 37.3 inches, correspond closely with the Scottish figures. These latter fish are fat and well nourished, as their coefficient of condition, 1.23, shows; they compare favorably with the most finely shaped Scottish fish. The younger group, however, besides having a small average size, have for their length a rather low coefficient of condition — 1.

The sex of each fish was given with the other details, but presumably was judged

from external examination only. The proportion of males seems unduly high, and the erosion of the scales also in many cases does not suggest that the sex has been accurately determined.

SALMON OF THE GRAND CASCAPEDIA RIVER

BY

W. L. Calderwood, I. S. O.

SALMON OF THE GRAND CASCAPEDIA RIVER

82 Newbattle Terrace
Edinburgh, 19th December 1926

DEAR MR. GRAY GRISWOLD:

I received the completed record of the Grand Cascapedia scales yesterday, and am now able to give you an account of them.

The leading group is the 3 winters in the sea. There are 94 of them, or 56.3% of the total. The only other group of any size is the 1 spawning mark lot. There were 47 of them, and of that number 33 were 3 winter smolts.

With regard to the 3 winters in the sea group, it has also to be said that a most noticeable feature is the age before the first descent to the sea. 52 of the 94 were 3 year old smolts, and more remarkable still, 32 were 4 year old smolts. There is no 1 year smolt. We have never struck such a high per-

centage in smolt age in any of our British scales. Here is the tale of the 167 samples in brief:

Percentage of Smolt Ages

Age Groups	*Years in River*				
	2	3	4	5	
2 + winters	9.1	54.5	36.4	—	
3 winters	8.5	55.3	34.1	2.1	
3 + winters	—	100.	—	—	
4 winters	—	100.	—	—	
Spawned	1.6	66.6	31.8	—	
Total	6	59.9	32.9	1.2	100

The feeding for smolts in the river must be rather exceptionally poor. If the majority of the fish spawn high up it is a hard country for their offspring. In Norway there are 5 year old smolts in the Finmarken province, which is within the Arctic circle.

With regard to fish which have previously spawned, none had spawned more than twice before the third ascent on which they were killed, *i.e.* they were potential 3 S M fish. There were 13 of these, and for fish which

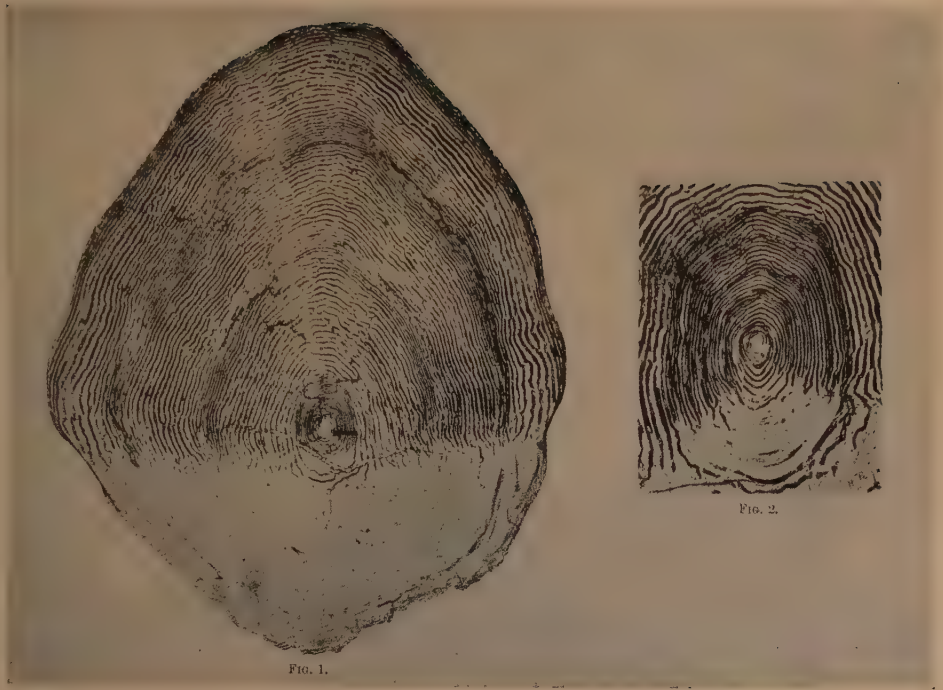


Fig. 1.

Fig. 2.

GRAND CASCAPEDIA SALMON SCALES

have been out of the sea reproducing their species, the weights are wonderfully good. They range from 29 to 41 lbs; and the average is 33½. Both the 29 and the 41 were 4 year smolts; 7 were 3 year smolts.

Now with regard to your heavy fish, only one is above 41, *viz.*, a 42½ lb. fish. It had been a 3 year smolt and had spent 4 continuous years in the sea. After that fish the heaviest lot are contained in the 2 S M group and are the 3 year smolt fish of that group. The weights are: 33, 39, 31, 31, 32, 32, 32. Five of the 7 were females, and one was a doubtful male.

A small fish of 6½ lbs. was marked as a grilse, but the scale reading showed it to be a small summer salmon, a 3 year smolt that had been 2 years and a bit in the sea.

One scale was regarded as that of a kelt, weight not given, length 41 ins., female.

The weights of your most numerous group, the fish which have spent 3 consecutive years in the sea, vary a great deal — from 13 lbs. to 32 lbs.

Of this crowd, those that were 3 year smolts average 23.1, which is just your river average, I think; those that were 4 year smolts average 24.3.

With regard to the youngest group — the 2 + winters — the average weight is 11.7, the average length 30.6 (2 of this group weighed 14 lbs. but a 6 and an 8 brings down the average).

That, I think, pretty well completes a résumé of the data collected except for calculated lengths at each year, and the condition factor, I need not perhaps trouble you with these, but with your permission I should like to put a note about the data in the Royal Society Edinburgh Proceedings here, and if this is done I will of course send you the paper.

With all good wishes for the festive season,

Yours sincerely,

W. L. CALDERWOOD

THE CANADIAN SALMON

THE CANADIAN SALMON

SALMO salar, at one time so numerous in the rivers of our East Coast, are now found only in the waters of the Dominion of Canada.

The rivers to which the salmon now return are not numerous. Many fish are taken yearly, both by rod and net, yet the salmon as a food fish has become a luxury.

There has been very little scientific study made of these valuable and most interesting fish, and nothing has been done to increase their number. There have been a few hatcheries installed at times on different rivers, but they have as a rule been unsuccessful.

I find that the anglers who control the rivers are most conservative sportsmen who diligently read what generations of Englishmen have written on the subject of salmon fishing and follow their advice implicitly.

They do not however follow their British cousins by studying the fish and by introducing methods to improve the rivers, nor do they try to rehabilitate those rivers that were at one time good salmon streams.

There were no salmon taken on the river Esk in England prior to 1872, but spawn had been introduced from the Tees for several seasons. The fishing improved year by year, and in 1924, 958 salmon were caught on the rod that averaged 13.43 pounds.

Twenty-five years ago there were practically no salmon left in the Wye. The stock had become depleted by over-netting. Messrs. Hotchkis and Hutton have by wise measures made the Wye into probably the greatest salmon river in the world. In 1927 the rods took over 6,000 salmon that averaged 19.1 pounds, including 31 fish of over 40 pounds each.

It is a strange fact that the rivers of Great Britain contain yearly *five times more salmon* than enter the streams of Canada.

Our rivers are mostly in the wilds and free

from poaching, while their streams often run through towns and villages in thickly populated districts, and have been fished for hundreds of years.

Their abundance in fish means three things: Nature in the first place, then wise laws, and a strict observance of the same.

The Grand Cascapedia had a great season in 1924. About 17 rods took 1,369 salmon weighing 30,591 pounds. In late October the head guardian counted the fish and estimated there were 4,450 salmon in the river and 500 in Loon Lake. If we double the total number to account for the fish taken in the local nets, and those overlooked by the guardian, it would make the total run for the river, in a very good year, but 13,000 fish.

In 1927, a good year, the rod score on the river Wye was:

6,145 salmon weighing 117,291½ pounds and the nets took:

4,662 salmon weighing 62,824½ pounds — a total of 10,807 fish weighing 180,126

pounds, a score that no river in Canada can begin to equal.

There were 4,464 salmon taken on the Ristigouche on the rod in 1927, 989 of which were killed on the tributaries.

Mr. A. H. E. Wood of Glassel writes that on the small Aberdeenshire Dee,[1] in a good year, from 10,000 to 15,000 fish are taken on the rod and even a greater number in the nets.

The Moisie rod record of 2,060 salmon in 1926 is small in comparison.

The scales of the Moisie and of the Cascapedia salmon have been studied and it has been ascertained that about 60% of the parr of the former river go to sea as smolts when two years old, but in the Grand Cascapedia 60% are three years old, and 35% four years old before they leave the river for the sea.

The longer the parr remain in fresh water, the greater is the number that are destroyed by their river enemies. The kingfishers, sheldrakes, loons, ospreys, and eagles all take toll

[1] There are no salmon hatcheries on these rivers.

of the little fish, but I believe their most destructive enemy is the trout.

British rivers also hold sea trout but they are not our fish, the *charr,* an expert cannibal. Sea trout abound in midsummer in the rivers of Canada. One afternoon last summer two rods took 40 trout on the Cascapedia that weighed from one half to five and one half pounds each.

The trout must displace the salmon parr as the amount of food is limited. A river can only support a definite number of *salmonidæ,* this number being determined by the amount of food available. When the food runs short the *charr* devour the small salmon.

It is not uncommon when salmon fishing to take a five pound trout and find a parr in its stomach.

When the salmon are on the redds shoals of trout lie in wait to devour the salmon eggs.

As we do not know where the salmon winter in the sea it is difficult to say what enemies they have there. It is however well

known that they have two enemies along our coast which are much more destructive than those in the eastern Atlantic, namely the brackish water, or white porpoise, with the local name of "white whale," and the seal.

The St. Lawrence River streams suffer from the white porpoises, especially in late years, as the natives have ceased to hunt them.

In Great Britain most of the rivers flow directly into the sea, so that it is possible for the authorities to control the nets. In the Wye netting is allowed but three days a week.

Most of our salmon rivers in Canada flow into the St. Lawrence River, or into the Bay of Chaleurs, so that the fish have a very long coastal journey on their way to fresh water.

There are gill-nets all along these routes, and the fishermen are allowed to net the salmon every day in the week excepting Sunday. It is said this law is complied with until the Inspector's launch has passed.

They now demand the privilege of fishing on Sundays also.

The weight of salmon captured in the nets is supposed to be reported to the Royal Fisheries Commission, but the honesty of these reports is questioned.

THE ROYAL COMMISSION REPORTS IN CWTS.

	NEW BRUNSWICK	PROVINCE OF QUEBEC
1911	13,017	8,410
1912	13,877	9,091
1913	17,985	12,761
1914	17,056	11,699
1915	17,867	11,795
1916	17,791	15,302
1917	15,983	13,532
1918	17,452	11,139
1919	9,668	5,807
1920	11,477	4,927
1921	20,383	7,805
1922	16,859	12,206
1923	20,682	14,765
1924	33,563	15,080
1925	30,073	20,714
1926	25,131	15,536
1927	22,464	14,840
1928	12,166	6,905

A catch of 20,000 cwt. would mean 100,000 salmon of 20 pounds each.

Total 2,754,995 salmon of 20 pounds each in eighteen years.

This means that the netting is excessive and that it is a wonder that sufficient salmon can possibly run the gauntlet for the purpose of reproduction.

It is hardly possible that the redds are damaged by the outgoing ice, but quite probable that the newly hatched young salmon may suffer greatly during the Spring freshet.

Most rivers do not freeze solid, for otherwise the numerous kelt would not be on hand in the spring. My guides tell me they have seen blocks of ice floating downstream containing frozen kelt.

Owing to a Spring and an Autumn run of salmon in Scotland the angler is allowed to fish as many months as we do weeks in Canada, yet owing to high and low water conditions he does not actually enjoy very many more days of sport than we do. Mr. Wood

writes that his limit on the Dee is four months subject to water conditions.

As they enjoy a longer season it is no wonder that they take more fish than we do, but that is not the question.

The question is: Why is the number of salmon that enter the rivers of Great Britain five times greater than the number that come to our streams in Canada?

THE SALMON FISHING SEASON OF 1928

THE SALMON FISHING SEASON OF 1928

WHY was the salmon fishing so poor in 1928? Why did so few fish come to the rivers of Canada?

The anglers have different opinions on the subject. Some say the shoals of fish have gone to Newfoundland by mistake; this cannot be so, for although single salmon sometimes wander, the shoals do not. The theory that there has been a great disaster at sea is not probable, because although the shoals of salmon from the different rivers may pass the winters at the same degree of longitude at sea, the latitude must differ, for it is many miles from the mouth of the St. Lawrence River to the Bay of Chaleurs.

There is a demand that the "white whales" be hunted and destroyed, for it is "owing to them that the salmon have dis-

appeared." The white whale is the Beluga[1] or white porpoise, that grows to over 1,000 pounds in weight and no doubt does great damage to the fish of certain rivers, but it is impossible that the supply of fish should fall in all the rivers the same year from that cause. The Belugas might assemble in numbers off the mouth of one river during a certain season, and create havoc, or perhaps the St. Lawrence might hold more white porpoises certain years than during others, but this year (1928) all the rivers of Canada were short of salmon.

Some wise men maintain that the lack of fish was caused by poor spawning conditions during 1922–23. A good spawning season is one of low-water conditions, for then the spawn is deposited in the bed of the river, but if the water happens to be high at that season, the salmon are apt to use the bars, shallows and sides of the river for that purpose. In the latter case, the redds are greatly

[1] There is also a Beluga Sturgeon — hence Beluga Caviare.

damaged when the ice goes out during the spring freshet. The tiny alevins must be destroyed in great numbers.

What was the spawning condition in 1922? We keep no records and no one can answer the question. One thing I know is that there was a goodly supply of salmon in the Cascapedia in the autumn of 1922, for the fishing had been fairly good.

During 1928, a very early and moderate run of old, large salmon, mostly over 30 pounds each, arrived in the Grand Cascapedia and went on up, leaving a few fish in the pools. No further run arrived. I saw only two fish bearing sea lice.

I took 27 salmon that averaged 25 pounds. Twenty-three of these fish averaged 28 pounds. The usual large run of *maiden six-year-olds,* 3–3, did not come at all.

Why did this happen?

In studying the question, the first thing I discovered was that 1928 is not the "worst season on record." *Nine* years ago — 1919 — was worse, and the season of

1911 — *eighteen* years ago — was equally bad.

On making this discovery, I remembered that Professor O. Pettersson has written that the *moon* and the *sun* have considerable influence on the waters of the earth, and that the tide generating force *varies* through a *nine year period.*

In other words, the currents along the coast move *off and on shore* in *cycles of nine years.* In this century, the nine year cycle at furthest off shore began in 1903. The cycles run to date:

1903 — 1911
1911 — 1919
1919 — 1928

In each of these cycles salmon fishing was at its worst in the years mentioned, namely in 1903, 1911, 1919 and 1928; *at the end of each nine year cycle.*

I discovered this by examining the scores of the rod catch of both the Grand Cascapedia and the Ristigouche Club.

The rod record, however, depends greatly on weather and water. More fish might be taken during a season of good water conditions, even though fewer fish were in the river, than during a season of poor water conditions. I find the reports from the nets agree with the rod scores. Their *poor* years agree, as also do their *good* seasons.

If what Professor Pettersson says is a fact — *"the nine year cycle"* — then it is possible to explain, not only the bad and the good years of salmon fishing in the rivers, but also the good and bad seasons of all schooling fish along our coast, which has always puzzled fishermen.

Bluefish and mackerel are plentiful some seasons, scarce during other years. They visit our shores in early fall to feast on Sperling. When that harvest is over they make off shore again.

Sperling, *Menedia notata,* are the small fish we now eat and call "whitebait."

The currents that are moved off and on

shore in cycles of nine years *carry the bait:* —

Squid, menhaden, sardines, anchovies, "sora," shrimp and numerous other school fishes, are at the mercy of the currents and float back and forth on the tides, for they have not the strength to stem them.

All schooling fish feed *en masse,* and must follow the *bait or starve.* As the said currents move off shore for four or more years, fewer and fewer bluefish and mackerel visit our coasts, but as the turn comes for them to move in shore again, the fish increase in numbers year by year, for *where the bait is* there you will find the schools of larger fish such as tuna, bluefish, mackerel and, further north, the herring as well.

As I find the *rod catch* as well as the *net catch* of salmon agrees with the nine year cycle, and that the *poorest* years of this century have been:

1903 — 1911 — 1919 — 1928

I presume that the shoals of salmon also

follow the bait, for they need much food and must feed also *en masse,* and where food is very plentiful.

I judge that those years when the currents are *far off* shore are the *poor* salmon fishing years on the Canadian rivers, with the *worst year* at the *end of each nine year cycle.*

I believe the salmon is more or less of a bottom feeder, for the adult fish has a square tail, and we know by the nets that shoals of salmon average only six miles a day by daylight. They do not travel at night in the sea. If they were surface feeders, we should long since have discovered where they pass the Winters and the Summers in the sea.

Anyone who has watched a school of bluefish feeding on menhaden knows what havoc they create. They destroy ten times the amount of food that they eat. Can it be possible that the shoals of salmon follow the surface feeding fish, below the surface and feast on the crumbs from the rich man's table?

As 1928 is the end of a nine year cycle,

only the heavy fish, that had been in our river at least once before, had the energy to return. The maiden 3–3's did not come; perhaps they were too far at sea for the fresh water from the rivers, which is their inspiration to return, to reach them, or else, a place where food is good and plentiful may be a more pleasant summer resort than a river when the journey is at its longest.

Those years, such as 1922, when the figures of the catch do not run quite true, can be explained perhaps by heavy easterly gales during the Winter of 1921–22, which shifted the currents closer in shore than they would be normally — the journey was not so long or the inspiration of the taste of the fresh water stronger, and more fish came than would have come under normal conditions.

If I am right, it will be easy to pick the four or five best seasons out of each decade in the future, that is, as to the number of fish to be expected. The actual fishing depends on weather, water, skill, and luck. It

also means that the salmon fishing will be poor in 1929–1930 and probably 1931. It should improve in 1933 and be good in 1934 and 1935.

	CASCAPEDIA CLUB	RISTIGOUCHE CLUB
	7 to 8 RODS	20 to 30 RODS
1911	141	969
1912	151	780
1913	162	1039
1914	149	1044
1915	186	1334
1916	337	1299
1917	390	1525
1918	336	1272
1919	209	589
1920	248	917
1921	206	1029
1922	413	1615
1923	434	1345
1924	589	1804
1925	567	1858
1926	543	1558
1927	480	1315
1928	190	711

THE ROYAL COMMISSION REPORT
of the Nets in Cwts.

	NEW BRUNSWICK	PROVINCE OF QUEBEC
1911	13,017	8,410
1912	13,877	9,091
1913	17,985	12,761
1914	17,056	11,699
1915	17,867	11,795
1916	17,791	15,302
1917	15,983	13,532
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1924	33,563	15,080
1925	30,073	20,714
1926	25,151	15,536
1927	22,464	14,840
1928	12,166	6,905

A catch of 20,000 cwts. of salmon would mean 100,000 fish of 20 pounds each.

Pau
September 7th 1928

Professor Otto Pettersson
Goteborg
Sweden

Dear Professor,

Would you have the great kindness to read the enclosed paper and let me know if there is anything in my theory? It all depends on your "nine year cycle of the tides" which interests me greatly. Our salmon run was very light in Eastern Canada this season (1928), and I am trying to find a good reason for it. I have your address from Professor Thompson who advised writing to you for information. Please pardon me for troubling you.

Yours Sincerely
F. Gray Griswold

15 Sept. 1928
Svenska Statens
Bevaknings och Undersökningsfartig
Skagerak

To Mr. F. Gray Griswold

Sir,

Being occupied with a hydrographic excursion in the Skagerak I have not got an opportunity to answer your letter of 7th Sept. before. The accompanying paper on the salmon fishing 1928 and the statistics from the beginning of this century I have read with great interest. I have hitherto only studied the periodicity of the herring fishery in the Northern Atlantic and was agreeably surprised to hear that the salmon is a fish that merits a study from the same point of view.

I herewith return the typewritten M.S. which I hope you will publish as soon as possible and send me a copy. I find the periodicity in itself a statistical fact worth to be noticed. Regarding your " working hypothe-

sis," or explanation, I must say that it agrees with my own ideas. In the last number of the Geographical Journal there is an important paper by the leader of the Discovery Expedition, Professor Hardy, who explains the rich "fishery" of whales at S. Georgia thus:

S. Georgia lies as a "breakwater" exposed to the current through the Drake Strait from the Pacific Ocean. This Antarctic Current carries immense quantities of diatoms. On the East side of S. Georgia it forms an eddy with relatively stagnant water. The copepods assemble there and are consumed by the fishes, whales, and so forth. This hydrographic situation makes S. Georgia the eminent whaling region that it is. We ascribe the migrations of fishes either to their want of food, or to their spawning instinct. If it here were question of migration in quest of food, I would ask if there had been any research made of the copepods in the Canadian waters, but as it is evidently the opportunity for spawning which attracts

the salmon shoals to the Canadian coast; "inspired," as you say by the fresh river water from the continent which can be more or less deflected by currents, there remains the possibility that the periodicity of salmon fishing may depend on periodicity in the current system of the ocean, and in the last instance on variations in the interaction between the Sun, Moon, and the Earth.

Yours truly
O. PETTERSSON

THE PACIFIC SALMON

THE PACIFIC SALMON

IT had been believed that all the salmon that were hatched in the rivers of the Pacific Coast went down to the sea before their scales were formed, and that they all returned when they were four years old to spawn.

When Professor Charles H. Gilbert made his scientific study of the scales of these fish he discovered much that was interesting.

Although these scales are formed in the same manner as those of the Atlantic salmon, their appearance differs. They lack the strongly marked smolt centre and have no spawning marks. This is quite natural, for the fish do not remain several years in fresh water before going to sea and they only spawn once and all die after spawning.

This is of peculiar interest as concerns this species, for as they all die at maturity the question of their age is of great importance.

"The scales of the Pacific salmon persist throughout life and grow in porportion with the rest of the fish, principally by additions around their borders. At intervals there is produced, at the growing edge, a delicate ridge upon the surface of the scale, the successive ridges then formed being concentric and subcircular in contour, each representing the outline of the scale at a certain period in its development. Many of these ridges are formed in the course of a year's growth. Spring and summer being a period of rapid growth, the ridges are widely separated, while the winter ridges are close together. These two areas constitute a year's growth."

In the early spring two sizes of young sockeye or red salmon have been observed on their downward migration to the sea. The larger are yearlings, which instead of going to sea the previous spring as fry, have remained in the lake during their first year. The smaller are the fry just hatched.

This happens also with the tyee or chinook and also with the coho salmon. The hump-

PACIFIC TYEE SALMON
Sixth Year

back and dog-salmon always migrate to the sea while in the fingerling stage.

All species of Pacific salmon cease to feed on entering fresh water on maturity.

It has been found that while the majority of the Fraser River run are in their fourth year when they return to the river, a considerable number of them, including all the larger individuals, are in their fifth year. The smaller fish which return are three year old grilse.

The largest variety, the chinook, tyee, or king salmon, run to a great size, it is claimed to 100 pounds. I have seen a tyee that weighed 72 pounds, and have taken them over 60 pounds in weight. The fishermen always insisted that these fish were only four years old, which I could not quite believe. From the investigation of the scales it has been ascertained that there are male fish of this species six and even seven years old that return to spawn. The females are mostly in their fourth year, and the small, so-called spring fish or sachems, which accompany the

run, are grilse, precociously matured males that are two or three years old.

Professor Gilbert's summary on the subject is:

1. The sockeye spawns normally either in its fourth or fifth year, the king salmon in its fourth, fifth, sixth, or seventh year, the females of both species being preponderatingly four year fish.

2. The young of both sockeye and king salmon may migrate seaward shortly after hatching, or may reside in fresh water until their second spring. Those of the first type grow more rapidly than the second, but are subject to greater dangers and develop proportionately fewer adults.

3. Coho salmon spawn normally only in their third year, but adults are developed almost exclusively from those which migrate as yearlings.

4. Dog salmon mature normally either in their third, fourth or fifth years, the humpback always in their second year. The young of both species pass to the sea as soon as they are free swimming.

5. The term "grilse," as used for Pacific salmon, signifies conspicuously undersized fish which sparingly accompany the spawning run. They are precociously developed in advance of the normal spawning period of the species. So far as known the grilse of the king salmon, coho, and dog salmon are exclusively males, of the sockeye almost exclusively males, except on the Columbia River, where both sexes are about equally represented. The larger grilse meet or overlap in size the smaller of those individuals which mature one year later at the normal period.

6. Grilse of the sockeye are in their third year, of the coho and dog salmon in their second year.

7. The great difference in size among individuals of a species observed in the spawning run are closely correlated with age, the younger fish averaging constantly smaller than those one year older, though the curves of the two may overlap.

THE SALMON OF THE PACIFIC COAST

BY

R. D. HUME

FOREWORD

MR. HUME, who wrote what follows, was a practical salmon breeder, but not a scientist. He made a fortune hatching salmon and canning their flesh on their return to the river.

The hatchery on the Rogue River is now in the hands of the Government, but the annual run of salmon has greatly diminished owing to excessive off-shore netting.

F. G. G.

THE SALMON OF THE PACIFIC COAST

THE salmon industry of the Pacific coast has furnished lucrative employment to thousands, and has been both directly and indirectly the means by which very many have made fortunes, and who without its benefits would perhaps find themselves out of employment and lighter in pocket.

In view of the great importance of this industry, it would seem the imperative duty of all engaged or in anywise interested in the business to protect and preserve, so far as is possible, the source from which the essential factor springs, namely, the salmon of the Pacific coast; and the best efforts of the minds of those who are in any manner familiar with the conditions which are favorable to that end should be turned in that direction. The writer, firmly believing in

the principles set forth in this section, although well aware that there is much yet for him to learn regarding the matter, proposes to give to the public as the result of the observations of a lifetime, a series of articles, wherein will be contained a history of the experiments made and experience gained by constant contact with the business in its various forms, hoping thereby not only to add his mite to the general fund of knowledge of the subject, but also to call forth from others such information as may have been gained by their experience, in order that, ere the streams of our State have been exhausted, and while such information may be of practical use, the public may receive the benefit.

For many years prior to the advent of salmon canning on the Pacific Coast, owing to the scarcity of these fish in other parts of the civilized world, salmon had become a luxury of which none but the wealthy could partake, and the writer, when a small boy, heard two of the wealthiest citizens of his

native town (Augusta, on the Kennebec river, in the State of Maine) argue for half an hour as to how a salmon of ten pounds weight should be divided so that each should get a fair proportion of the fat, and which should have the head part; and finally, after appealing to the large crowd of bystanders for their opinions regarding the question, at length settled the matter by cutting the fish on an angle, from belly to back, so as to give the one with the tail portion a fair share of the belly; and then paid $1 per pound for their portion, and went home with smiles on their faces and eyes glistening in anticipation of the glorious feast they were to have on the morrow.

At this time, which was about the year 1853, the catching of a salmon at this point on the Kennebec river was of rare occurrence, usually the catch for a season being three or four, and a half dozen being a large take for the year. At this time the principal supply of salmon for the markets of the United States was procured from the Penob-

scot river in Maine and the waters of the British provinces, namely: Mirimichi river, and the rivers putting into the bay of Chaleur; and these could be obtained only in limited quantities, and at a great expense to the consumer. Up to the age of eighteen, the time the writer left home for the Pacific Coast, although some of his family were engaged in the fishing business, it had never been his fortune to taste salmon but once, and it is doubtful if but few in that State of his age had ever seen one. What a blessing came to the poor with the establishment of the salmon canneries, and with their progression, an increasing benefit, to the extent that in 1892, allowing one can for two persons, which is amply sufficient, one hundred and thirty-five millions of poor people could enjoy, once in a year, such a luxury — and considering the amount of nutrition and ability to satisfy the appetite, at less than the price of any kind of flesh food.

In the early days of the salmon business South America and Australia furnished the

consumers for the product, but as the supply increased a market in England was sought, which at first did not take kindly to the American product; but by the persistent efforts of a few of the principal dealers in food products (one of the most active of which was the firm of Pelling, Stanley & Co., of Liverpool, now one of the largest distributors of canned salmon in the world) the article became known, and the people of Great Britain in a short time became the principal consumers. A great deal of the prosperity enjoyed by the business is due to the efforts of these gentlemen, who were pushing, progressive people, their perceptions being alive to the fact that in this new product was embodied a nutritious food supply for the masses at the lowest possible cost, as compared with the products of other descriptions. I well remember the story of Mr. Pelling in regard to his experience with the first lot of 500 cases of salmon that he had purchased — of his efforts to get his customers to take a few cases for trial, and his

arguments to them that canned salmon were to furnish Great Britain a cheap and nourishing food for her laboring population — his failures to get buyers to take hold of the new goods, and his daily walks around the pile of cases to see if any had been disposed of; his discouragement when observing that, though a long time had elapsed, the pile seemed as large as ever. But after a time by patient and continuous effort, allied to the fact that the article had the merit claimed, he brought the consumptive demand of Great Britain up to 450,000 cases per annum. Not much effort was made to create a demand in the United States until the increase of the pack had overloaded the other markets, at which time a new factor came upon the scene, in the person of J. K. Armsby, of Chicago, who now occupies much the same relative position in the United States, as regards the distribution of canned salmon, as does Pelling, Stanley & Co., of Liverpool, to the same line in the English market. To Mr. Armsby is due in a great

measure the rapid extension of the demand for this article in the United States, although there are many other prominent dealers.

In view of the fact that the salmon supply is a matter which, as a figure in the food question of so many millions, is of much importance, as well as being the source of so much wealth to the Pacific Coast, it certainly would seem strange if the people of this country did not feel disposed to foster both the business and the source from which it derives its life. It is the desire of the writer to present such facts for the consideration of his readers as will shed some light upon a question which, although it has been treated in various forms by very able writers for more than forty years past, still, in view of the success made by the operation of any plans laid down in the various works upon the subject, or benefits derived from legislation upon the matter, seems yet to the great majority as being in an experimental state. The first point to consider in this connection

is the question, What were the conditions of the various streams when the salmon supply was most plentiful? And it is easily answered: There is no question but salmon were most plentiful before civilization had begun its work, and when dams, traps and other obstructions and hydraulic mines were unknown, when the sources of the river were unsettled and undefiled by the sewerage of the cities, the forests at the headwaters still untouched by man, and the country yet in its natural state.

The effect of a change of conditions can be best indicated by a description of the situation on a few of the salmon streams that have been either wholly exhausted or rendered practically useless for commercial purposes in this branch of industry, and those that are rapidly approaching that condition.

Taking the Kennebec river, which was a fine salmon stream at the early settlement of the country, and reflecting upon the possibility of the supply's being maintained under the conditions which were in effect in the

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year 1853, the mind is easily satisfied as to the causes which led to the almost total extinction of these fish. By this time cities were located within a few miles of each other all along the banks, discharging their sewerage and waste from gas and dye works into the stream, while at Augusta was situated a dam which was impassable for any sort of fish, no provision for a fish ladder having been made, until through the exertions of Seth Green (who has been justly termed the father of fish culture in America) about 1857 one was constructed, but was soon allowed to get out of repair, and was of no practical use. There were also a large number of sawmills delivering their sawdust and other waste into the river, the timber was being rapidly removed from the tributaries which formed the headwaters and spawning grounds of the stream, while the lower part of the river, in Merry Meeting bay and other favorable locations, was lined with traps to such an extent as to render the escape of a fish almost an impossibility, and only a very narrow channel was

left for the passage of steamboats, and this running in such a serpentine course as to require a skillful pilot to work the vessel through.

The Sacramento river, prior to the introduction of hydraulic mining in 1853, was, during the running season, so plentifully stocked with salmon that no use could be made of but a moiety of the supply, and we have an illustration of the destructive force of this new agent when we consider the fact that eleven years after its introduction the Sacramento river was practically rendered useless for commercial purposes as a salmon stream.

The Klamath river furnishes another illustration of the destructive action of hydraulic mining upon the salmon streams of the coast. In 1850 in this river during the running seasons, salmon were so plentiful, according to the reports of the early settlers, that in fording the stream it was with difficulty that they could induce their horses to make the attempt, on account of the river

being alive with the finny tribe. At the present time the main run, which were the spring salmon, are practically extinct, not enough being taken to warrant the prosecution of business in any form. The river has remained in a primitive state, with the exception of the influence which mining has had, no salmon of the spring run having been taken except a few by Indians, as a reservation by the government has been maintained, until within a few years, and no fishing has been allowed on the lower river by white men; and yet the spring run has almost disappeared, and the fall run reduced to very small proportions, the pack never exceeding 6,000 cases, and in 1892 the river producing only 1,047 cases.

The next and most important river on the coast to receive consideration is the Columbia, and this, though not yet exhausted, has shrunken its output since 1883, in the number of cases produced, more than one-third, and according to good authorities the product of 1892 was but little more than 150,000

cases of true adult Chinook salmon, the balance of the pack being steel-heads, blue-backs, and a small salmon of a variety which will later receive attention. This, if true, would show a fearful decrease in the past nine years, amounting to more than three-quarters of the supply of the quality packed when at its best; and from both packers and fishermen comes the cry that, although the demand for the article is good, they are unable to make living profits from the prosecution of the business. A contemplation of this proposition leads one to inquire what have been the conditions that have brought about such a result, when since 1883 the number of canneries on that river have decreased considerably, and during the time a hatchery has been in operation, which has turned out millions of young salmon every year.

Prior to 1879 traps and fish wheels cut a small figure in the methods of taking salmon on the Columbia river, the few traps in operation being mostly in the vicinity of Oak

Point, the lower river about Astoria being free from their influence. Since 1883, however, the number of traps at Astoria and fish wheels on the upper river have rapidly increased, with a corresponding decrease in both the quality and quantity of the salmon packed on that stream, as well as a rapid falling off of the profits of the business. The question will naturally be asked, in view of the difficulties surrounding the proposition, can the supply be maintained in such a manner as to protect the industry? This I answer in the affirmative, if the operations towards stocking the rivers are maintained in a proper manner, and the right sort of legislation is had upon the question of taking the product of the rivers.

While I quite agree with my contemporaries upon many of the questions regarding the varieties, culture and habits of salmon, there are some of the most vital points upon which I shall be compelled to take issue with them, the first of which is the question whether all the small salmon taken by the

traps and fish wheels are a distinct species; the second being whether they are all male salmon and all perish after making the first trip to the spawning grounds; and the third, do all adult salmon die after spawning?

As a brief answer to these questions, which will be treated more fully in a later article, I will say that outside of the variety known as blue-back, which is a distinct species of salmon, and the young steel-heads, which are quite numerous, the grown members of whose family are a valuable adjunct to food supply, the great bulk of small salmon, as observed by me, are the young of the true Chinook salmon; and I deny that it is a fact, as is claimed by some very intelligent gentlemen, that all young salmon taken by the traps and fish wheels are males, and consequently might as well be caught, but will state that in the female grilse at the age of two years not even a sign of eggs can be found, and that they could be easily mistaken by a careless observer for males, unless the male was very near the spawning time,

when its seed would have developed in such a manner as to make such a mistake impossible. Neither can I agree with the proposition that, conceding they were all males, all perish after having made their first journey to the spawning grounds; and I should feel obliged to any reliable gentleman who has seen any number of the true Chinook salmon, in their two-year-old form, without regard to sex, lying dead about the headwaters of the Columbia or any other river on the Coast, who would communicate the fact, as so far I have been unable to obtain information of that kind. While it is without doubt that in streams of great length the adult salmon die after spawning, it is also a fact that in the shorter streams very many return to the sea after having done so, and it is unreasonable to suppose that the Creator has so deviated from the law which He has established with all else in nature as to have created salmon with such an excess of the male species, and that millions could be thus cut off prior to maturity without damage to

the perpetuation of the whole class. In view of this phase of the question, what other remedy can be suggested than that during the running season of the salmon grilse traps and wheels should either suspend operations or make some arrangement whereby the small salmon may escape — a provision for which in their construction could be easily made. In no river having a spring run should be taken any variety of salmon of less than five pounds in weight. It would seem an unprofitable proposition to undertake to keep up the supply with hatcheries, if their output is to be taken in two-year-old form, thereby losing at least four-fifths of the weight which might be gained in another two years of growth. A strict observance of this rule, together with a reasonable quantity from the hatcheries, would keep up the supply at least, and would probably increase it.

Another very important factor in the preservation of the species would be the establishment of stations on the lower river, where, after the spawn had been taken and

cared for at the hatcheries on the natural spawning grounds until the eye spots were formed, and the eggs able to bear transportation, and the final hatching and turning loose could be done. In my estimation, ten thousand young fish turned out in a healthy state, at a time when they are able to take care of themselves in the lower river, just above the influence of brackish water, are of more value to the river than one hundred thousand turned out at the headwaters, for the reason that at the spawning and hatching time trout, and fish of all kinds which prey upon the eggs and young, congregate at the headwaters and gobble up both eggs and young fish by thousands. The turning out of large numbers in a small stream attracts their enemies of all kinds, beside giving the young fish an insufficient supply of food, from which lack many perish from starvation. By following this plan the young salmon would be where their enemies would not be able to find them, as well as being able to obtain the food supply of the whole stream.

A careful attention on the part of the fish commission of the State regarding obstructions which prevent the salmon from reaching the natural spawning grounds, such as dams and traps, placed entirely across the streams, would be a powerful factor towards the preservation of the species; and the passage of a law which would make it a crime for taking or having a gravid or spawning salmon in possession, except for spawning purposes, with the assistance of the other factors mentioned above, assisted by the operation of such hatcheries as the importance of the business seems to justify, would enable the industry to remain as permanent a branch as that of agriculture.

Professor Baird often said that " one acre of water was worth seven acres of land, if properly cultivated," but I am convinced that the Professor erred only in this, that I believe one acre of the waters of any salmon stream in Oregon, if judiciously cultivated under favorable circumstances, and if not paralyzed by ignorant or vicious legislation,

is worth more as a medium for the product of a food supply than forty acres of the best land in the State. The fact, however, that there are many different streams which produce salmon that have their runs at different times in the year, and also that the same river may afford runs of different kinds at various times in the year, makes any laws heretofore passed, which apply to the seasons they have sought to close, inapplicable to the necessities of the case, and productive of more harm than good. In view of this position of affairs I would submit the following plan to my readers, which to my mind, in addition to the preceding sections, seems the only way of taking a grasp of the whole question with any certainty of realizing a benefit:

Let an act be passed by the legislature which shall provide for the appointment of a Chief Fish Warden for the State, who shall have deputies in every county, whose duty it shall be to take note of the different runs of salmon and trout in his district, and report the same to the head of his depart-

ment; and an act which shall provide that in parts of such streams, wherein lie the natural spawning beds, no fishing for salmon or trout shall be done for one month prior to, nor at any time during, the spawning time of the different runs, and making it the duty of the fish warden to close such portions of the stream by posting notices at various stations along the banks, denoting such portions as shall remain closed to fishing, and also to publish notices in the nearest newspaper to the same effect, and any violation to be punished by a heavy penalty. Also an act providing that no salmon of any variety in any of the rivers of the State of Oregon should be taken by traps, fish wheels or seines, of less than five pounds weight.

I will add that unless some such steps are taken, in less than ten years the packing of salmon on the Columbia river will have become impossible as a business proposition, and in much less time the truth of this proposition will become apparent. But by the passage of the laws mentioned, and the

adoption of the suggestions herein contained, the salmon supply would be kept up without interfering with any other branch of industry, for reasons that will appear in future treatment of other branches of the salmon question.

A SHORT TREATISE UPON THE COMMERCIAL VARIETIES AND THEIR HABITS

A SHORT TREATISE UPON THE COMMERCIAL VARIETIES AND THEIR HABITS

THE varieties of the genus *salmo* are classed by many ichthyologists as being of fifty-two distinct species, which includes all varieties of the trout family, but owing to the slight difference in the appearance of many which are named, there has been a great diversity of opinion in regard to the question. The fact that in rivers which enter the sea within a few miles of each other, as well as the different tributaries of the same river, the fish will have local characteristics which enable those who are familiar with the various streams to distinguish to which river or tributary they belong, should cause little surprise that there was some confusion in regard to the question. The character of the water, alkaline or otherwise, temperature,

color of the gravel which forms the spawning beds, color of the timber, light and shade at the headwaters — all have their influence in the marking and coloring of these fish. A consideration of the character and habits of the whole family would, however, call for more ability and occupy more space than is allotted to the writer, therefore only those varieties used for the purpose of canning will receive attention.

First, and most valuable, are the *Salmo Quinnat,* or Chinook salmon, which are to be found at different times, according to locality, between the months of March and October, in varying quantities, in nearly all the rivers of the Coast, from the Sacramento to Alaska, and are known at the latter place by the name of King salmon. The duration of their run also varies with the locality, and their quality depends upon the season in which they are taken, those of the spring and early summer months being so much superior in fatness and flavor as hardly to be recognized as belonging to the same species,

when prepared for the table. Certain conditions seem necessary to produce a spring run of Chinook salmon, among which is that the river must take its rise in the mountains of the interior which are clad in everlasting snow, the melting of which produces an early spring freshet, the fresh waters extending a long distance into the sea, producing a growth of feed that is favorable to their reaching a high state of development, thus preparing them for the long and arduous journey they must make in order to reach the spawning grounds. The only rivers of the Pacific Coast which seem to furnish the conditions necessary for a spring run of salmon are the Columbia, Sacramento, Rogue and Klamath.

In these rivers Chinook salmon begin to run during the month of March, and a few have been taken even earlier, but are limited to small quantities until about the middle of April, and generally continue until about the first of August, although some seasons may cut off a few days earlier or continue a

short time longer. The different runs, according to the date of their arrival, have their particular objective point, those coming earliest making for the extreme headwaters, while, according to the order of their coming, later arrivals fall into tributaries less and less remote from the sea, until the last to come spawn in the main river.

Those which reach the headwaters spawn during the month of August, and later runs in their order during September and October. It seems necessary for the maturing of the eggs of this species that the fish should remain in the fresh water about four months, and the writer will state that for years past it has been the custom at his hatching pond to hold salmon nearly that length of time, to let the fish ripen for spawning, even after they had been held in the river for some time prior to being placed in the ponds, and this without supplying them with any sort of food, which seems to settle the question regarding their taking food, while they are in fresh water for the purpose of propagation.

However, this is not the case with the Silversides, as they will, while in the bays, take a hook readily. The Chinook salmon of the streams which take their rise in the Coast Range of Oregon, and those called King salmon in British Columbia and Alaska, are (making due allowance for the local influence of the streams wherein they are caught) identical in character. The running time of this branch of the family also varies with different streams, those on the Oregon coast coming in during August and September, but not ascending above tide water until after the fall rains of the early part of November, and spawning from the 1st of December to the 15th of January; while on the coast of California they are considerably later, and in Alaska much earlier, in some of the streams running as early as June and spawning in July.

The most important of all, except the spring Chinook, as regards quantity, and by many considered superior in quality to all except them, is the Blue-back, as it is called

on the Columbia river, Saw quai in British Columbia, and Red salmon in Alaska, where they are found in large quantities. The quality of these fish also depends largely upon the locality where they are found, the Columbia, Frazer, Skeena and Nass rivers producing the best. This species of salmon seems to seek, for spawning purposes, those rivers that are formed by the outflow of lakes to which they can have access, and their spawning time is from July to October, according to locality. The adult salmon of this species weighs from six to eight pounds, and their flesh is the richest red color of any variety used for canning purposes.

The Silversides of the Oregon coast, or Silver salmon as called in Alaska, are an excellent fish for the table when fresh, but on account of their pale color are not so highly esteemed in the markets when canned, as the public taste has been educated to expect a bright color as evidence of quality; but there are many engaged in the business who prefer these to the red salmon of Alaska for their

eating. The greater portion of these fish that find a market are packed on the coast of Oregon, and their run begins about the middle of September and lasts until the early rains, when they leave the bays for the spawning grounds, spawning from the middle of December until February, although both running and spawning seasons vary slightly in the different streams.

The Steel Head, or as it is variously called, Sea Trout, Bull Trout or Salmo Trutta, ranges in weight, when mature, from three to twenty pounds, although some attain even a larger size, and as regards quality are about on an equality with the Silversides. This species may be found in the rivers at almost any season of the year, but their principal running time is from January to March, and their spawning season in April and May. After spawning they return to the sea with small loss in numbers from the effect of propagation. Having noted the different varieties used for canning and the various seasons in which they make their appearance,

we will now escort a couple of the most royal of all classes, the spring Chinook, to the headwaters, and endeavor to trace out the object and result of their journey, as well as some of the difficulties which they encounter. These fish make their appearance outside the bar for several weeks prior to entering the rivers, drawing nearer as the time progresses, as it seems for the purpose of gradually becoming seasoned to the change from salt to fresh water, which would seem necessary from the fact that a salmon taken from fresh water and placed at once in sea water will die immediately, and it is reasonable to suppose that the reverse would have the same effect. After having entered the fresh water portion of the stream, they move up the lower portion of the river at a speed ranging from fifteen to forty miles per day, according to the nature of the stream, but as they ascend the more rapid portions at the headwaters their rate of speed becomes greatly diminished.

After having arrived at the spawning

grounds they settle in some deep, shady pool, just below a wide shallow riffle or gravel bar, where the water is from one to two feet in depth, and runs with a moderate speed and a straight current from bank to bank, without eddies or obstructions, which cause varying currents. There they remain, comparatively quiet, until within about two or three weeks of spawning time, when the male moves up to the riffle and begins the formation of the redd, or spawning bed. This he does by rooting with his nose and pushing away the gravel with his powerful tail until he has made a hole or pit several feet in depth. In his efforts he often makes a sorry sight of himself, by having worn his nose until a good portion of the head is gone, and the best part of his tail and fins have also disappeared; nor is he left undisturbed to perform his labor, as when he has nearly completed his bed, after a severe battle, another that is stronger may drive him away and take possession, and he is obliged to seek another place and build again. After the

redd is prepared and the female is ripened, she moves up alongside where the male is standing guard, and they deposit together the eggs and milt, at the same time with a movement of their tails sweeping the gravel over them to protect them from the myriads of other fishes that are lying in wait to gobble them up, and this they can perform with only a small degree of success, as the trout are so persistent that in spite of being fought away by the parent salmon they will return and lie so close as to seize the eggs almost as fast as dropped. After the work of propagation is completed they still remain on guard, fighting away any other fish which may go upon the spawning beds, until, worn out with their exertions they will float down the stream dead, with the exception that when a sudden freshet comes in the river some of the stronger ones may be swept down to the brackish water, where, although they arrive sick and sore, they take on new life, their sores are healed, and in four months they are as lively and plump as ever.

In verification of this proposition the writer will state that at his hatchery the adult fish, after spawning, have been marked and returned to the river, and four months later have been caught, and that they were in as fine condition as ever, beside having increased considerably in weight. I will also state that at the spawning time the male fish had the hooked nose and long teeth, which in some localities gain for them the name of Dog Salmon and that when they were first put into the ripening ponds, and when taken the second time (the following spring) they showed no such peculiarity, the disfigurement being caused by the wasting process incident to the preparation for fecundation, and the fact that no food was taken in the meantime, causing a shrinkage of the flesh about the mouth, leaving the teeth exposed, and a contraction of the muscles of the face which draws the nose or beak into a hooked shape.

As we have now accompanied the lucky individuals back to the sea and noted the

result, we will now take another trip to the spawning grounds, to see what has become of the object of their long and arduous struggle.

The eggs, after having been deposited in the gravel, if not disturbed by a heavy freshet, which often sweeps away all of them to destruction, lie secure from all enemies except those that can work into the recesses where they are hidden, for a period which depends upon the temperature of the water. The higher the temperature the more quickly they are hatched, but with the temperature forty-five to fifty degrees they will hatch in from forty to fifty days, while in Alaska, with the temperature at from twenty-six to thirty-five degrees, it has taken five months and a half before they began to break the shell of the egg. After breaking the shell in which it was confined, and with the umbilical or yolk sack attached, it is a helpless little object, its only protection being its instinct to dive into the sheltering depths of the gravel, where it remains, with-

out taking food, until the yolk sack is absorbed, at which time it ventures forth in its search for food, and at this time becomes the helpless prey of trout and many other enemies. Another source of destruction is a disposition on the part of the young fry to ascend every little branch or rivulet as far as they can get, and these little watercourses often drying up leave thousands of these little fish to die in its bed. Herons, kingfishers, cormorants and birds of several other kinds gobble them up by hundreds, and it is almost surprising that any escape. It is estimated by good authorities that of the number of eggs deposited, upon which different writers vary considerably, some placing the number as high as 12,000 for an adult female, not more than three per cent of which ever come to maturity in the natural process of hatching. While I have no doubt regarding the per cent that mature, I am satisfied that the number of eggs carried by the salmon has been much magnified, as I have repeatedly counted the eggs of the

Chinook salmon at times when there was no possibility of any having been lost, and have always found exactly four thousand — two thousand in each roe.

About fourteen months from the time of hatching, a portion of the young salmon start on their journey to the sea, while the balance remain in fresh water another year, and many are caught by line fishermen under the mistaken idea that they are brook trout. Those that have descended the river on their way to the sea remain in the bay for a short time, and then are lost sight of for about four months, at the expiration of which time they return with such an increase in weight as to appear almost incredible, leaving the river when about seven inches in length, weighing but a few ounces, and returning weighing from four to five pounds, while a few reach a weight as high, even, as eight pounds. This, astonishing as it may appear, has been demonstrated at the Gold Beach hatchery, which is situated near Indian creek, to which the young salmon

migrate when turned out of the hatchery, and from which a ditch is taken from the upper part to supply the hatching ponds with water. About fourteen months after hatching, unless the ditch is shut off from the head on account of too much water, these young salmon come down the ditch and into the ponds from which they were turned the year before, and have been caught, marked, and turned out into the bay, where they were again taken four months later, with the result stated. Another peculiarity is that while the young salmon, on their first trip, remain but such a short time in the sea before ascending to the spawning grounds, the female does not show even a sign of spawn in the roe, while many young males will become fertile, and even the young males of the same hatching that have not yet made the trip to salt water, although but a few inches in length, will get into the same condition.

In view of these facts, at what other conclusion can we arrive than if adult salmon, which enter the river in April, deposit their

spawn in the month of August, and remain until the freshets of November force any surviving members towards the sea, making due allowance for the time necessary for seasoning to stand the full strength of the sea water, that these fish spend but a short time in the ocean, and while there take on a wonderful growth, they therefore would not be likely to journey far from the streams to which they are common, and it would account for the fact that each river has salmon that are in some particular peculiar to itself. It would also appear that were those who claim that all salmon die after spawning correct, as well as those who claim that all young salmon that ascend the river do the same, it would necessarily follow that one trip of each class would be an end to the whole of this species that belong to that river. With many of the theories that have heretofore been generally accepted, regarding both the habits and culture of salmon, I must disagree, as the light of my experience has shown their fallacies; and it is also with as-

A LOG JAM

tonishment that I hear persons at this day, in view of the success made in other branches of pisciculture, and with the knowledge of the destruction caused by the encroachments of civilization, making the assertion that all that is required to keep up the supply is to allow a portion of the run to ascend to the spawning grounds, that have been, or are in the process of being, destroyed by every method known to civilization.

I contend that without reasonable exertion for the erection and operation of hatcheries, and the exercise of wise laws for the protection of the spawning grounds, and regulating the size of fish to be taken, the States of Oregon and Washington, which now enjoy a monopoly of the finest quality of salmon in the world, will have soon lost their heritage. The lack of interest manifested by those engaged in the salmon canning business on the Columbia, in the matter of their propagation, is surprising, when very many are aware how simple and inexpensive is the process of merely hatching the

eggs — in fact, so simple that any cannery could have a small hatchery, and by obtaining eggs in which the eye spots were formed could finish the process, and when the fish were well developed distribute them with little trouble in the fresh water branches nearest their location. They could also procure eggs, if by concerted action they would establish ripening ponds at the mouths of some of the small streams that put into the lower river, similar in character to those in use at Gold Beach, a description of which will be given in a future discussion of the subject.

THE ART OF SALMON CULTURE

The Apparatus Necessary for Propagation

THE ART OF SALMON CULTURE

The Apparatus Necessary for Propagation

IN order that any readers who may be stimulated by what is herein contained to undertake the propagation of salmon may avoid the mistakes and difficulties which were made and encountered by the writer in his early attempts, and the very considerable expense consequent thereto, a short history of the early part of the undertaking may prove useful, as well as furnish some evidence to substantiate the conclusions to which I have arrived in former articles regarding other branches of the question. More than twenty years ago I suggested to the packers of the Columbia river that as other streams, which were formerly abundantly supplied, had at that time become practically exhausted,

something should be done toward stocking the river; but I was generally met with the remark "that the salmon would last as long as they would need any." A few years, however, convinced them that they might be mistaken, and the result was the location of a hatchery on the Clackamas river in Oregon.

Hearing that salmon of a fine quality were very plentiful at the Rogue river, I purchased a location and built a cannery there the latter part of 1876, and in the spring of 1877, much to my surprise, packed only 3,197 cases, which was all that could be obtained by the utmost exertion, which proved that the reports, except as to quality, were but echoes of the past; and thus I was furnished with the necessity as well as the opportunity to put into practice those crude ideas which had long been forming in my mind. As soon as I realized how few salmon the stream afforded, operations were begun towards stocking by excavating a pond for holding and ripening the adult fish, on a little spring branch which afforded about one

thousand gallons per hour, during the dry season, and that put into the river about a mile from the bar or entrance, and a small hatching house was built close by the pond. After completing the pond and house I stocked the pond with one hundred adult female salmon and fifty of the male species of the finest specimens that could be selected. After this was accomplished I made a trip overland to the hatchery on the McCloud river, a tributary of the Sacramento in California, for the purpose of observing the operation of spawning, etc., arriving there in the early part of August, and although the superintendent was away the men in charge kindly went through the operation for my benefit. After making note of the various items of interest I proceeded to San Francisco, where by the kindness of mutual friends I was introduced to the Hon. B. B. Redding, then secretary of the fish commission of the State of California, who proved to be very enthusiastic on the subject of salmon culture, and who, when I stated

that I was in pursuit of information upon the subject, advised me to engage the services of a young gentleman by the name of Kirby B. Pratt, who had been employed at the McCloud hatchery for a number of seasons; and acting upon the suggestion I engaged Mr. Pratt, and we at once made our way to Rogue river, when Mr. Pratt took charge, and against all difficulties with which he had to contend, in spite of the fact that he had previously had no experience with fish that had been kept in retaining ponds for the purpose of ripening, from one hundred females, in the following spring succeeded in turning out three hundred and fifty thousand healthy salmon. After turning out the young fry, on account of poor health Mr. Pratt was compelled to seek a more genial climate, and thus we were deprived of a valuable assistant in our efforts.

Having made such a success in the beginning, the next season I determined to so prepare that we should correct the weakness of our system of the year previous and make

a much larger output, and with this in view made the pond larger, planked and tarred it, increased the water supply, cut away the timber that heretofore had shaded the place, and made quite a clearing, beside many other, as we thought, improvements about the place. When the season had arrived we placed a fine lot of salmon in the pond, but much to my surprise in a short time they began to swim about near the surface of the water, showing white patches in various parts of their bodies, which kept growing worse until they were covered by a growth of fungus, their eyes blinded, and finally nearly all died, leaving only enough to give us about fifty thousand eggs. At this result of what I had considered would enable me to surpass any previous efforts, I was much disheartened, but finally concluded that the trouble came from the planking with which the pond had been enclosed, and that a liberal use of coal tar would correct that, and then everything would go along in good style. So the next year I tarred liberally, but

on placing the fish in the pond the same thing occurred. By this time I was so much worked up over the question that I determined to make a radical change. I would no longer trust planked ponds, but build with stone, and as there was a point of solid ledge on the up-river side of the cannery I had the earth piped away from a portion of it down to the solid rock, and built a concrete wall around, enclosing a space forty by sixty feet, and turned in a much better water supply than ever before, believing that I had at last solved the question, and in my mind's eye seeing many young salmon ahead. You can imagine my disappointment and disgust when, after repeating the operation of the year before, the same result occurred. To add to my eagerness to succeed, the crop from the first year's planting came in that year, and for a time the river seemed alive with fish, while with all the force we could muster we were not able to take care of half that might have been caught.

The evidence of the value of propagation being so forcibly brought to my mind made me very anxious to succeed, and I would spend hours on the point above looking at the poor creatures paddling about the surface of the pond, and worry myself sick in the effort to discover a remedy. One day while occupied in this manner I began to reflect upon the proposition, and asked myself the question, under what conditions was the greatest success of this undertaking made? And the recitals of conditions came in this order: a little pond, a little water, a great deal of mud, and so much brush and trees that the place never got the sun. "Eureka!" I cried, "*I've got it!* That is what has been the trouble!" I at once began the construction of a building over the pond that would close out the light, and when completed put in a new lot of salmon, with the result that they showed no signs of the previous trouble. When the building was closed the place became so dark that the fish remained perfectly quiet, probably having the

idea that they were in a deep pool, while previously they were bruising themselves badly in their attempts to find an outlet. If the letting in of the sunlight would produce such an effect upon the fish that were in a pond, the bottom and sides of which were constructed from solid ledge and concrete, with the water at a depth of ten feet, and fed by a pure stream, would it not seem reasonable that the removal of the timber and undergrowth at the headwaters of a stream would produce the same result? Would it not also indicate the origin of the so-called salmon disease which has afflicted these fish in the rivers of Great Britain?

Having shown some of the difficulties attending my first efforts toward propagation, before dealing further with that question I will briefly note some of my impressions regarding the work at the McCloud hatchery, which is mentioned in the early portion of this article. For several years this hatchery was maintained by the government of the United States, and from seven to

twelve millions of eggs taken each year, that were distributed in almost every civilized country in the world, but with no apparent beneficial result, which to my mind has had the effect of discouraging in a great degree the government from extending any considerable aid to the salmon hatcheries of the Pacific Coast. That this experiment should prove a failure should cause no surprise when it is realized that the spring variety of the Chinook salmon, or *Salmo Quinnat,* which is common to only a limited area of our coast, and in but a few of our longest rivers, is a creature of conditions of such peculiarity as are found in no other rivers of the world, viz.: rivers of great length, that take their rise in the everlasting snow and flow through a country of such temperate climate that ice is seen in them but occasionally, and then only for a very short time. I firmly believe that like conditions must be had in order to bring about like results, and that to transplant salmon successfully they must be placed in rivers where the natural

conditions are similar to those from which they have been taken.

To begin a description of the process of propagating salmon artificially, the first to be noted are the ripening ponds, although if eggs can be obtained from fish at the natural spawning grounds these would not be necessary, although very useful as feeding ponds for small fish. At Gold Beach we have two ripening ponds, about forty by sixty feet each, and ten feet in depth, one of which extends into the river to low water mark, which enables us at high water to come alongside with the racks or crates which contain the adult salmon and dip them into the pond without much trouble. The second pond is located upon the bank above, and first receives the water supply, which falls a distance of about thirty-five feet, and afterwards discharges through the waste way into the lower pond with a fall of about fifteen feet, which aërates the water sufficiently, so that two hundred miner's inches will keep five hundred ripening salmon, if

divided equally in the two ponds, in good condition for the purpose of propagation. The pond nearest the river is built on a solid ledge bottom, with walls of concrete, while the upper is of concrete altogether, and each being separately covered by a low roofed building, arranged to shut out as much light as possible.

The hatchery building is eighteen by forty-eight feet, with the walls about eight feet in height, and is constructed in such a way that by closing the shutters it can be made quite dark inside. On the banks above the hatchery, and connected with the water main by a pipe through its bottom, is a tank for filtering the water which is used in the hatchery, which tank is twelve feet long, four feet wide and three feet deep, with a partition in the middle which extends from the bottom to within six inches of the top. In the space where the water first enters is a filter made of alternate layers of coarse gravel and charcoal, while in the next are three flannel screens in frames that slip

into slides which are set on an incline, so that the pressure of the water will hold them in place. The water, flowing up through the charcoal filter and over the partition, passes through the screens and is carried by a flume to another tank of the same size and kind, except that it has no charcoal filter. This is set across the end of the hatchery building, and has two outlets, six by twelve inches, one of which discharges into a distributing tank, fourteen feet long and eight inches deep by twelve inches wide, inside measurement, and the other into another distributing tank of the same size just below the first, each outlet having gates or slides to shut off from the filtering tank and divert the water from the upper to the lower tank, or the reverse, as desired, for the purpose of cleaning out any sediment that might be deposited without stopping or interrupting the flow of water through the hatching tanks or troughs. These extend lengthwise of the building and join on in pairs to the lower distributing tanks, the end of the hatching

CLEANING UP LOG DRIVE

trough having a partition which comes flush with the sides, and is set on an angle to suit the incline of the trough, and butts up to a joint against the distributing tanks, which has a notch three inches long by one and a half inches deep cut in its side to match a corresponding notch in the end of the hatching trough, where it butts against it, for the purpose of letting the water flow into the hatching troughs. The extreme length of each set of hatching troughs is fifteen feet seven inches, and they are placed at a grade of three inches for their length. These are followed by another set placed in line on the same grade, which receive the water which passes through the first set. The troughs are nine inches deep and twelve inches wide, inside measurement, with partitions six inches high, to form a series of dams or riffles, and set in two feet six inches apart from center to center. About six inches from each end of the space enclosed by the partitions a rod of iron one-quarter inch in diameter passes through the

trough about three-quarters of an inch above the inside of the bottom, for the purpose of forming a resting place for the hatching baskets, so that a space may be left between the basket and the bottom of the trough, so that as the young fish are hatched out they may work through the mesh in the bottom of the basket into this space. The object in making the troughs so much deeper than the partitions is to prevent the young salmon, after the sac is absorbed and they become lively, from jumping out, and that of placing the troughs in double lines is to save room and make a good passageway between the different lines of troughs, so they can be easily worked in picking out dead eggs. We have three double lines, two sets in length, with passages on all sides, and these have the capacity to turn out one million five hundred thousand fish, if worked to the fullest extent. After the water has passed through the hatching troughs it falls into a long flume, which forms the waste way which comes from the end of the dis-

tributing tank, where there is a gate to regulate the pressure of the water that passes into the hatching troughs, and the surplus runs into the waste way, and this discharges into a tank on the floor or scaffold in the ripening pond, a portion of which is floored over on a level with the wall for the purpose of handling the fish when spawning. This tank is about six feet long by four wide and two feet deep, and discharges into the pond. All tanks, troughs and waterways are given a good coat of tar every season, both inside and out, as well as all flumes leading to filtering tanks. The hatching baskets are two feet long, ten and a half inches wide by six inches deep, the mesh of which is one-eighth of an inch wide by three-quarters of an inch long, and an excellent one is made after the writer's model by A. S. Hallidie of San Francisco.

Next come the tables (with their dumb clocks on the wall back of them) upon which to set a dozen six-quart pans which hold the impregnated eggs, one pan under each clock,

which is set for the time that each operation has to be passed through, so that when the time has arrived which agrees with that marked by it the next manipulation takes place. Close by the table is a small sink or shallow tank about three feet long by two feet wide and six inches deep, and a tap to draw water as required for washing the eggs after impregnation. Next come the mid-wives, which on account of their peculiar shape are difficult to describe. These are made of white cedar or spruce sides attached to a back piece that is hollowed out to fit the back of the fish, and the sides are cut away to leave the belly exposed, tapering from the tail end toward the head for about three-quarters of its length, the balance being left square. A headpiece is made which fits over it, and can be telescoped back and forth to suit the length of the fish, and fits over his jaws, while the tail is held in place by a strap. This, although but a crude description of the apparatus, may serve as a hint to the beginner, who may, by the exer-

cise of a little inventive ability, construct what he needs for the purpose.

A couple of dip nets of fine twine and small mesh (the smaller the better), about three feet deep, and hung in a hoop of steel made of three-eighths rods, and two feet across, attached to a pole or handle about ten feet long, and three or four five-gallon oil cans with the tops cut out and a piece of wood nailed across the inside of the top part to serve as a handle, and with a couple of holes cut on opposite sides, with some pieces of fine-mesh wire web soldered over them to permit the escape of surplus water and prevent fish from getting out when water is added in transporting the young fish from the hatchery to adjacent streams, with the exception of a few brooms and buckets, complete the list of articles necessary for the purpose of salmon culture.

THE ART OF SALMON CULTURE

Propagating the Fish

THE ART OF SALMON CULTURE

Propagating the Fish

WHEN the spawning time arrives, the first to be done is to turn on the water through the filtering tanks into the hatching troughs, and put in place as many baskets as are considered necessary for the amount of eggs expected to be taken during the day. When all is in order and the tank that receives the waste is filled and overflowing, two of the operatives with the dip nets begin the search for ripe fish, and when one is secured they place it in the midwife, then put the midwife with the salmon in the waste tank, where it will keep alive and in good condition for a few hours. They then resume the search for another salmon of the opposite sex, and when they have secured one,

place that also in a midwife. While one operator seizes the one in the waste tank and sets it on end with the vent of the fish down, the other does the same with the last one caught, while the third operative holds one of the pans under the vents of both fishes, which have been brought as near as possible to each other. The manipulators then gently press the bellies of the fish with a stroking motion, from the throats downward to the vents, to discharge the eggs and milt simultaneously into the pan; and at the same time the person holding the pan, with the end of his fingers resting on the bottom of the pan, in order not to jam the eggs, gently stirs the eggs and milt together. When the fish are well ripened this operation consumes but a couple of minutes, and it is very essential that the operator should be particular not to undertake to spawn unripe fish. It is very easy to select ones that are ripe, as in the female the eggs have been separated from the roe when ready for spawning, and when the fish is set on the end with the vent down, the eggs will

settle toward it like shot to the bottom of a sack, which will cause a shrinkage of the upper part toward the throat; while the male, when ripe, if handled will eject the milt with a spurt. After this operation is performed the pan is placed gently on the table and allowed to remain quietly from fifteen to twenty minutes, after which water is poured gently down the side of the pan until the eggs are covered to the depth of an inch or two. They then are allowed to remain in this condition for an hour, during which time the milt, which in the first operation has formed a curd, fastening all the eggs together, will have become separated.

The operator then takes the pan to the washing tank, which has been filled with water from the tap, and a constant stream kept passing through it, gently dips the pan into the water, with a swinging motion floats the milt or curd over the edge of the pan, until the eggs are well cleaned from it. It will then be discovered that while the eggs when

first taken were of a pinkish color, now that impregnation has taken place they have become the color and have the appearance of rich ripe currants. After the washing is done the operator takes the eggs to the basket which is in the hatching trough, and places the edge of the pan in the water close to the upstream end of the basket, and with a gentle sifting motion toward the other end deposits the eggs. This may be repeated until the basket contains from sixteen to twenty thousand eggs, the smaller quantity being the better, as it provides for the spawn of four salmon, and gives better results in hatching, besides making more room for the young fish, as they hatch out and drop through the bottom of the basket into the space below, where, if too much crowded, they do not thrive so well.

After having placed the eggs in the hatching troughs the hatchery is kept darkened as much as possible, and they are allowed to remain without being disturbed in any manner until twenty-four days have elapsed,

at which time they are examined and any dead eggs picked out. As this is a great departure from the rules laid down by many authorities, who insist on picking out the dead eggs as fast as they appear, I will say that my experience would tend to show this mode of operation to be wrong, as we formerly operated in that way and I have seen a basket of eggs that were properly impregnated destroyed by being picked over before the eye spots and yolk sac were fully formed, they dying faster than the operator could pick them out, although there seemed at the beginning to be very few dead ones in the basket. Since adopting the plan of leaving the eggs undisturbed until the twenty-fourth day after spawning, our losses have been less than one and one-half per cent, which is a better result than I believe can be shown by any other method of operation.

Another departure from the old style of hatching trough that we have made, is that instead of having a double set of partitions,

the water passing over one and under the other, causing a boiling or eddy in the section where the baskets are placed, we use only one, the surface of the water passing over the eggs with a natural riffle, they lying undisturbed below, while the water does not deposit so much sediment as in the old style trough, besides allowing the use of a greater volume of water. While in full operation our hatchery is using in the first stage of development about sixty gallons of water per minute. After the twenty-fourth day the flow of water may be increased to seventy-five gallons per minute with good results. While the eye spots are to be seen in from eighteen to twenty days, the membrane which forms the yolk sac does not become firm enough to permit handling the eggs with safety until past the twenty-third day, while after the thirtieth day, by being kept cool and moist, and being packed in wet moss, they may be kept for several days and transported hundreds of miles, and when again placed in the hatching troughs will go

on with the process of hatching. Sometimes in picking over the eggs to remove the dead ones, some that were good have accidentally fallen on the damp floor of the hatchery and lain for several days; when picked up, and again put in the basket have hatched out as well as any. The appearance of the eye spots, as well as the hatching of the fish, depends on the temperature of the water, the time mentioned above being with the water at a temperature of forty-five degrees, and the beginner will be governed by any variations of temperature, but must not disturb the eggs until four days after he has discovered the eye spots, which will appear as two little black specks close together on one side of the egg.

After the dead eggs have been removed, which will be easily distinguished on account of their having turned white, all that needs to be done, is to keep the water passing with regularity through the hatching troughs, keeping the light shut out of the hatchery, and look at the eggs once every two or three

days, picking out any that may have been injured in the first operation of picking. When the eggs begin hatching and the young fish commence to work through the bottom of the basket, it is well once a day to gently tilt the basket, first at one end and then the other, to allow them to work down through the unhatched eggs into the space below. When the eggs begin hatching, place fine-mesh screens on the outlet of the waste tank, so any of the young fish that may be carried by the current over the partitions may not be lost. After all in the basket are hatched, which will sometimes take several days from the time they begin breaking the shell, let them remain undisturbed in the hatching troughs, and in about thirty-five days, with the water at forty-five degrees, the yolk sac will have become absorbed, and they are ready to take feed, which must be given sparingly and pulverized finely. After being fed a week or longer, according to the quantity on hand and supply of food to be conveniently had, they are ready, if desired,

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for distributing, which is done by shutting off the water flowing through one line of troughs at a time, and placing one of the five-gallon cans mentioned under a vent in the bottom of a section where the baskets rested, then by withdrawing a plug which is driven in the vent from the under side of the hatching trough, draw the water and young fish into the can, which will safely transport twenty to thirty thousand young fish, with proper management, although if any distance is to be made, a less number is easier to manage. After as many as are required for the day's planting have been drawn off, the water is again turned through the hatching trough, the cans are placed in a skiff, the best sort having a platform in the stern, with a bulkhead to keep the water out of the body of the skiff and permit the overflow from the cans to pass overboard. If the river is fresh, the person having the fish in charge keeps dipping the water from the stream and pouring it into the cans, and if salt, the can must be set in a large tub of

water, which can be dipped from, poured into the cans, the tub receiving the overflow, the water being aërated by letting it fall in small quantities at a time from a height of one or two feet. Arriving at the mouth of some fresh water stream the young fish are turned out above the action of salt water, when they at once begin their journey up the stream and our labor is over. It has been the practice at the Gold Beach hatchery to turn out but a portion of the hatching in the manner above mentioned, while of the remaining portion the larger part are kept in the hatchery until the spring run of salmon begins, and in the meantime are fed upon canned salmon taken from what are called do-over cans, that have been left from the year before. When the cannery starts in the spring we turn out the young fish, which, as the water in the bay is perfectly fresh at that time of the year, remain near the cannery wharf and feed from the waste which is thrown out after canning their relatives. As soon, however, as the river gets low and

the brackish water begins to encroach upon them they move off up the river and into the adjacent tributaries. The young fish remaining in the hatchery are turned into the ripening pond and are fed with the immature eggs taken from the salmon while canning, upon which they thrive wonderfully, growing in the same length of time to four times the size of the young of the same hatching that were turned into the tributaries, and become so fat and plump that they are nearly equal in measurement in all directions. When they are four or five inches in length, by taking a sharp razor a person who is of delicate touch can cut off the dormant fin, which is located on the back nearest the tail, in that way making them so that they may be easily recognized when caught after returning from the sea, which has been done at the Gold Beach hatchery. The same process as is herein described for the propagation of salmon will also apply to the culture of trout, if the appliances are reduced in proportion to the size of the fish and oper-

ated in the season when their natural spawning time comes. The product can be kept in retaining ponds of like character, and when grown taken as required.

In this brief treatise on the art of salmon culture, it has been my endeavor to place before the reader a plain and simple statement of those methods which in my experience have been found most practical and producing the best results, without such a complication of description as to befog the mind of, and render the work of no practical use to, the beginner in the art of pisciculture, but rather a safe guide to any who may desire to engage in the undertaking for their own benefit, as well as that of the community in which they are situated. While the writer does not lay claim to having accomplished any great results compared to what might have been easily possible, a recital of the adverse conditions under which the work has been carried forward will enable the reader to understand under what difficulties we have labored. One of our greatest troubles

was the water supply, which at its best is limited to a small quantity, and in the time it is most required nearly drying up. The Gold Beach hatchery is also located within three-fourths of a mile of the ocean, hundreds of miles below the natural spawning beds of the earliest spring Chinook salmon, which adds greatly to our difficulties, as when the salmon have just entered from the sea they are very delicate, not bearing any rough handling, besides retaining in ponds for such a length of time as is required for them to ripen calls for constant watchfulness in order to keep up a steady water supply. To this is added the difficulty of obtaining the adult salmon alive to put in the ponds, as the fishing on the river is done entirely by gill nets. The fish taken by them cannot be used, as when the mesh of the net gets into the gills the fish are sure to die; and in order to get fish for the ripening ponds we have to use seines and float the fish in crates for several miles, besides handling them several times when they are the least able to endure

such treatment. It would seem that in view of the simplicity of the methods and certainty of success of salmon cultivation, good evidence of which is shown by the operations of our neighbor in the Dominion of Canada, who in 1887 had established nine salmon hatcheries, by which they have kept up the supply in the various sections of their country, together with the showing made by the writer, whose work has increased the supply of spring salmon in Rogue river nearly fourfold, in spite of very adverse circumstances, the record showing that it is the only river in the world where fishing has been done steadily each season that has shown such an increase, while the fall run in the same river, which has not been propagated, has fallen off in as great a proportion, should satisfy any reasonable mind as to the value of salmon culture, and stimulate not only those engaged in the business of canning, but the State and general government, to assist and encourage in every way possible the cultivation of this excellent fish. If the writer, by the

feeble efforts which appear in any of the preceding pages, is able to awaken any to the importance of, and necessity for, speedy action, he will have been amply repaid for his exertion.

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The Life history of a salmon

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